SC 5/13

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Change
Stages 1 & 2
and Background

A Unit for teachers

Published for the Schools Council by
Macdonald Educational

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First impression 1973
Second impression (with amendments) 1974

ISBN 0 356 04105 0

Macdonald Educational
49-50 Poland Street
London W 1

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Made and printed by Waterlow (Dunstable) Limited

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General preface

'Science 5/13' is a project sponsored jointly by the Schools Council, the Nuffield Foundation and the Scottish Education Department, and based at the University of Bristol School of Education. It aims at helping teachers to help children between the ages of five and thirteen years to learn science through first-hand experience using a variety of methods.

The Project produces books that comprise Units dealing with subject areas in which children are likely to conduct investigations. Some of these Units are supported by books of background information. The Units are linked by objectives that the Project team hopes children will attain through their work. The aims of the Project are explained in a general guide for teachers called *With objectives in mind* which contains the Project's guide to Objectives for children learning science, reprinted at the back of each Unit.

2530340

Acknowledgements

The Project is deeply grateful to its many friends: to the local education authorities who have helped us work in their areas, to those of their staff who, acting as area representatives, have borne the heavy brunt of administering our trials, and to the teachers, heads and wardens who have been generous without stint in working with their children on our materials. The books we have written drew substance from the work they did for us, and it was through their critical appraisal that our materials reached their present form. For guidance, we had our sponsors, our Consultative Committee and, for support, in all our working, the University of Bristol. To all of them we acknowledge our many debts; their help has been invaluable.

Metrication

This has given us a great deal to think about. We have been given much good advice by well-informed friends, and we have consulted many reports by learned bodies. Following the advice and the reports whenever possible we have expressed quantities in metric units with Imperial units afterwards in square brackets if it seemed useful to state them so.

There are, however, some cases to which the recommendations are difficult to apply. For instance we have difficulty with units such as miles per hour (which has statutory force in this country) and with Imperial units that are still in current use for common commodities and, as far as we know, liable to remain so for some time. In these cases we have tried to use our common sense and, in order to make statements that are both accurate and helpful to teachers we have quoted Imperial measures followed by the appropriate metric equivalents in square brackets if it seemed sensible to give them.

Where we have quoted statements made by children, or given illustrations that are children's work, we have left unaltered the units in which the children worked – in any case some of these units were arbitrary.

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No man can step twice into the same stream

Heraclitus, *fl.* 513 B C

1 What kind of work can be done in Stages 1 and 2?

1.1 Introduction

The work in this Unit arises out of situations which the child meets with in his own world. However, in order to extract the 'science', teachers need to know the potentialities and then to guide the children so that they become aware that there is something to be investigated. They need starting points, encouragement and careful questions to get them started. Examples of this approach can be found also in other books of the Project.

This is a teachers' book. It is written for teachers and does not necessarily use language which is appropriate for children. Many of the ideas need translating before they are suitable for the circumstances in your classroom. However, all the work which is suggested has been successfully attempted and completed by children during the trials.

1.2 Stage 1 work

This is an extension of work started in the infant schools where perhaps the science was based on the Project's book *Early experiences*. Basically we are trying to encourage children to ask such questions as 'What is it that changes?' and 'What changes are there in properties?' Perhaps we need to focus children's attention on change and to get them to look for it, to question it and not to accept it as inevitable. They need to look for differences: as has already been said, you cannot think of change without recognising differences, because they cannot recognise change without observing differences.

1.3 Stage 2 work

Now with increasing maturity, children, if they want to, can investigate change much more thoroughly. Perhaps along the following lines:
a. Less obvious changes can be studied.
b. So far studies of change have been mainly directed to the material side, but now more immaterial changes come into the picture, changes of ideas and opinions, changes of behaviour, perhaps even changes of energy can be looked at.
c. Energy should begin to be appreciated as a vital factor bringing about change.
d. The importance of time in change might be recognised; very slow changes of geological time contrasting with the rapid change of an explosion.
e. Perhaps children might begin to realise that a big change, such as a seasonal change, may be made up of a lot of little changes or that an apparently simple change is really quite complex.
f. Sometimes a number of changes complement one another and there is a snowball effect; this happens particularly with pollution in the environment.
g. Sometimes the effect of widespread change can be studied in more detail; this might be for some pupils an introduction into the consequences of an action, particularly those of a social nature, for example what effect had British Standard Time on people?

The children of one school situated in the middle of a redevelopment area set about collecting records of how the area and its people had altered since the school was built in 1871. This was a large and valuable study because theirs was the last opportunity to make records before the people were dispersed and the bulldozers moved in.

1.4 Six important questions

The basic ideas for studying changes become apparent if we ask ourselves the following six questions:

a. What is changed ?
- Matter
  - Composition
  - Physical properties
  - Physical arrangement
  - Position
  - Movement
- Non-matter
  - Energy
  - Environment (a collection of relationships)
  - Thoughts
  - Behaviour

b. Can the change be easily reversed ?
- Permanent eg cooking, burning
- Reversible eg melting, freezing

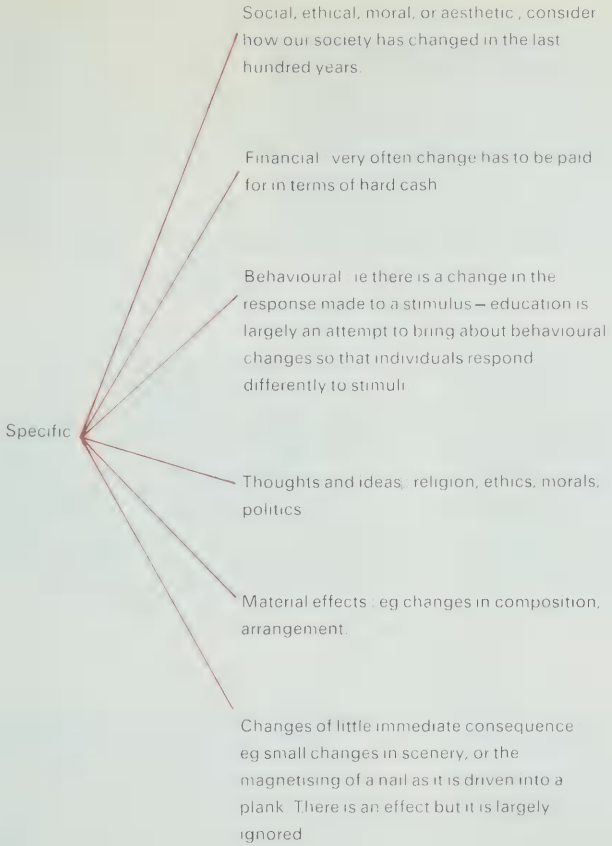
c. What is the cause ?
- Man-made
  - Deliberate
  - Unintentional
- Natural (causes other than man-made)

d. How do we observe the change ? or What is the effect on our senses ?

For example
We might classify some changes into making things appear to be :
bigger/smaller,
nearer/farther,
stronger/weaker,
heavier/lighter, etc.

e. What is the effect of the change ? This could be :

General
- Predictable : according to some pattern, eg if the weather gets cold enough to freeze.
- **Random: ie although the over-all effect is possibly predictable by statistics given sufficient data, the specific events are not eg the half-life of a radioactive element can be predicted but not which particular atom will disintegrate in the next five minutes, or another example is that seventy-five per cent of the population will catch cold this winter, but we do not know the names of the people who will catch a cold.**
- Unpredictable : perhaps because of insufficient data ; a pattern may exist but is unrecognisable due to lack of information. So far we cannot predict the weather, of say London, for twelve months in advance.


Specific
Social, ethical, moral, or aesthetic , consider how our society has changed in the last hundred years.
Financial very often change has to be paid for in terms of hard cash
Behavioural ie there is a change in the response made to a stimulus – education is largely an attempt to bring about behavioural changes so that individuals respond differently to stimuli
Thoughts and ideas, religion, ethics, morals, politics
Material effects , eg changes in composition, arrangement.
Changes of little immediate consequence eg small changes in scenery, or the magnetising of a nail as it is driven into a plank. There is an effect but it is largely ignored

All these effects, either quickly or slowly, tend to alter our environment which is made up of the physical world around us, our conduct and perhaps our framework of ethics.

f. Is it worth it ?
Do we want this change to take place ? If we do what is its effect and what will it cost us, and what must we pay for it with ?

These basic ideas form a pattern of objectives a teacher might have in mind when helping his pupils, but it is not being suggested that 'change' be taught formally, it is probable that ideas about change and its implications are best taught incidentally in the first instance. Pupils might well be encouraged, in the general course of their work to ask the questions:

i. Is there a difference ?
ii. What is changing ?
iii. What is the cause of the change ?

When they are accustomed to doing this with some confidence the idea of change as an important recurring theme might be broached, until finally, when they are mature enough, they can profitably discuss:

iv. How much do we pay for this change ?
v. Is it worth it ?

1.5 The Unit and objectives

The Unit contains suggestions for things children might do when exploring and investigating a particular subject area: these are easily recognisable and are printed in brown ink.

It also contains objectives since one aim of the Project is to encourage teachers to work 'with objectives in mind'. These are less easy to recognise, and their function in the Unit is not so apparent as the children's activities. Here we 'set the scene' for objectives but we strongly recommend that teachers read the book *With objectives in mind* for fuller understanding.

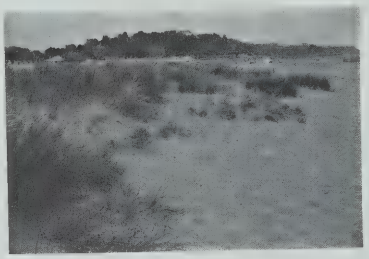
Broadly speaking, objectives are statements about what children might achieve from their work. They occur throughout the Unit, explicitly stated or implicitly there.

1.5.1 Recognising objectives in the Unit

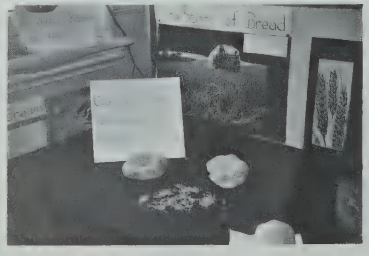
The 'Objectives for children learning science' will help. You will find this at the back of the book. It is reprinted from *With objectives in mind* and all objectives in the Unit are taken from it.

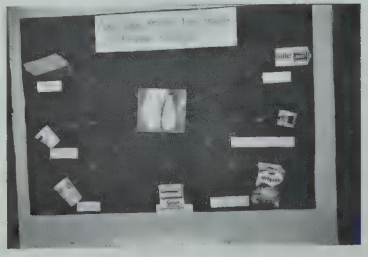
There are two things to notice about the statement:
i. The objectives have a particular arrangement based on their relationship to the Broad Aims* of the Project and

**You will find a diagram of the Broad Aims and an explanation of the Stages accompanying the statement.*

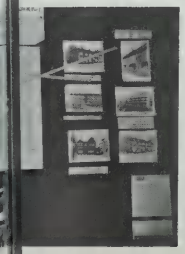


Change in





y aspects



to the stages of children's development which we have called Stages 1, 2 and 3.
ii. The objectives are numbered to indicate this relationship. The system of numbering is simple:

The FIRST digit	indicates whether an objective is at Stage 1, 2 or 3.
The SECOND digit	indicates the Broad Aim under which the objective is located.
The THIRD digit	identifies the individual statement.

For example: the objective *'ability to construct models as a means of recording observations'* is numbered *2.74.* The number *2.74* has the following meaning:

2	*7*	*4*
This shows the stage in children's development to which the objective chiefly applies – in this case 'Stage 2'.	This shows the broad aim to which the objective is expected to contribute–in this case *.70 'Communicating'.*	This shows the position (arbitrary) in the list of Stage 2 objectives that contribute to *'Communicating'*

The numbers are useful labels, allowing easy reference to a particular objective without quoting it in full. They do not imply any order of priority among objectives.

1.5.2 What do the numbers in the margin of the text mean?

Apart from the section and paragraph numbers you will notice other numbers in the margin of the text in this Unit. These are the numbers of objectives from the main statement that are relevant if children embark on the suggested work. They are included to help teachers think about objectives implicit in particular situations.

1.5.3 The Index to objectives will help

You will find this at the back of the book. It relates to objectives occurring in the Unit listed against the pages on which they occur. The lists are preceded by an explanatory introduction to the index which indicates how it can be used within the Unit and also in conjunction with the General index of objectives at the back of *With objectives in mind.*

These three sources of information will help you to work 'with objectives in mind'.

1.6 Why is some of the text printed in brown ink?

This Unit contains suggestions for children's work with a certain amount of background information for teachers. Children-based work is printed in *brown.* Information for teachers, not usually suitable for children unless translated, is printed in *black.*

1.7 Starting points and group working

Both of these subjects are dealt with in some detail in *Science from toys Stages 1 & 2 & Background* and *Metals Stages 1 & 2.*

2 What can we do?

2.1 Change as a component of other topics

It is suggested that change might be one of the important ideas that could be looked for when pursuing other topics, for example when dealing with 'colour' or 'structures and forces'. In this respect *Change Stages 1 & 2* could be thought of as a Unit containing ideas that can be woven into other topics. As one teacher said: 'I thought of "change" not as a unit but rather as a way of looking at the outside world.'

The advantage of using a topic in this way is that a large variety of experiences is obtained. However, unless some form of recording is used the relationships of these experiences are likely to be forgotten. It might be that a book could be kept so that various members of the class can enter their examples of change; or perhaps some sort of running exhibition in a corner of the classroom maintained by the children. Every so often the idea might be re-examined and a display mounted. All this would help children to collect experiences and with the aid of the teacher tie them together.

If change is looked for in other topics then some of the ideas mentioned in Chapter 1 might provide leads and pose meaningful questions which with suitable help could help children to widen the fields of their investigations.

2.2 Topics about change

In this section (see Chapters 3 and 4) a number of topics on change have been dealt with very briefly in order to show the capabilities and scope of the over-all theme.

Then, one topic 'Changes in the kitchen' has been given in some detail to show how a topic might be developed.

Some teachers have suggested that chemistry would provide a number of topics involving change but formal chemistry with its techniques, specialised language, ideas and equipment is best left for children who are ready to receive its philosophy in surroundings which are specially adapted to provide the services and safety factors needed. There are two important considerations:

Is the work or investigation appropriate for your children ? Can it be carried out safely ?

To paraphrase one of Napoleon's maxims, 'when in doubt, don't'.

2.3 Flow charts illustrating possible lines of development

Flow chart A concerns change out of doors.

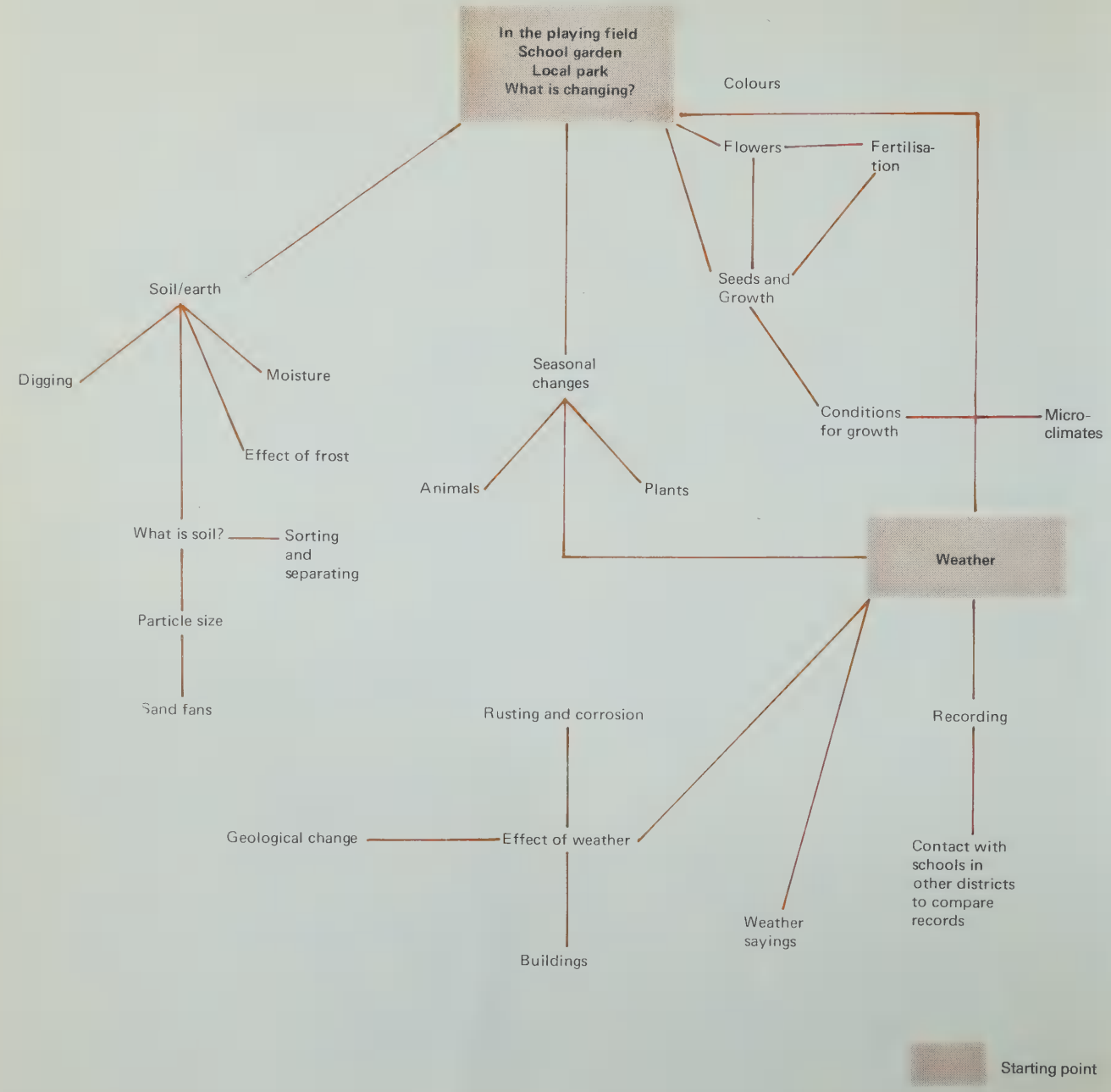
Flow chart B is about change and movement.

Flow chart C deals with change in the kitchen.

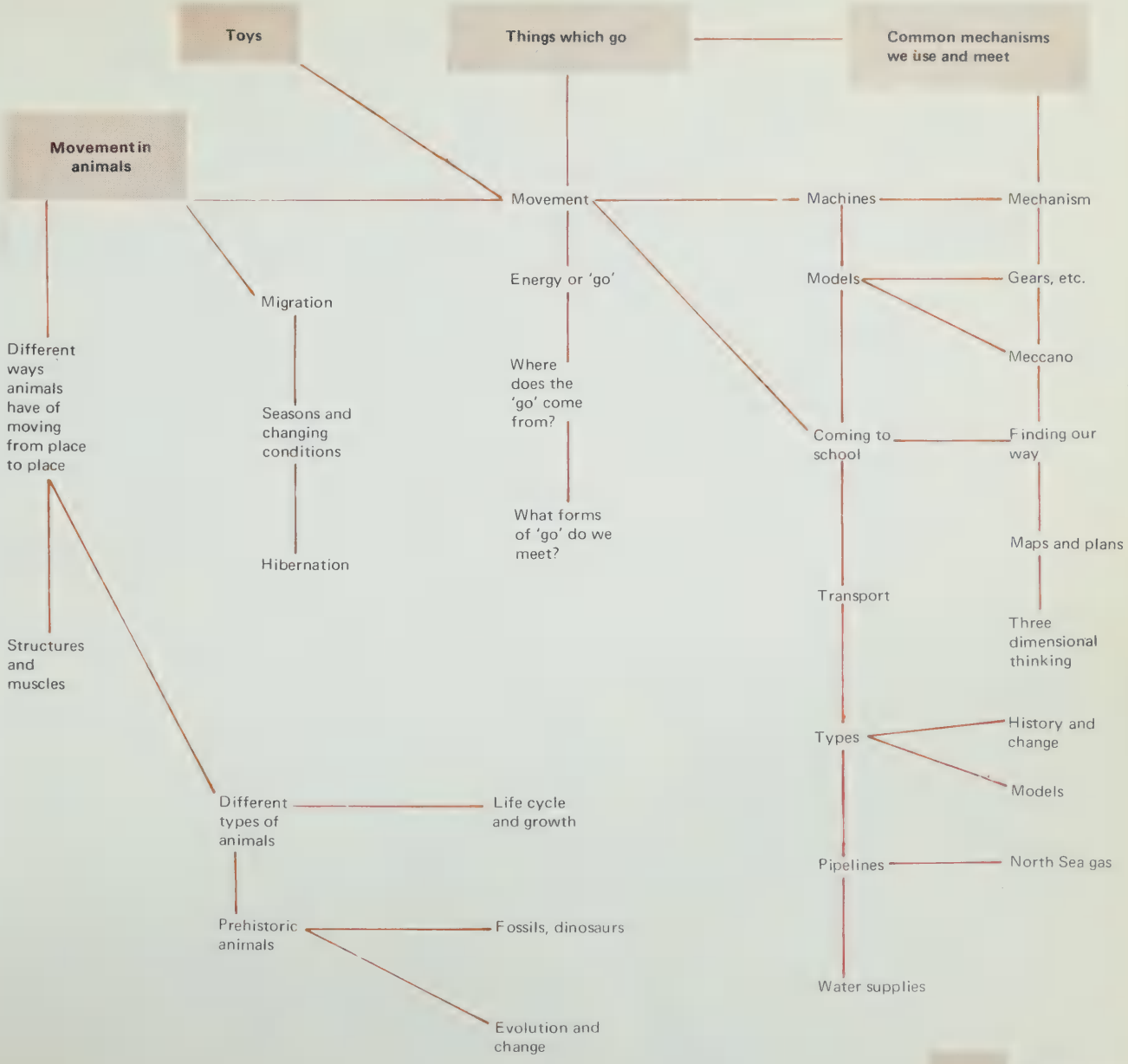
These flow charts are composite. They illustrate the development of work by several teachers all working independently on the same topics but using different starting points.

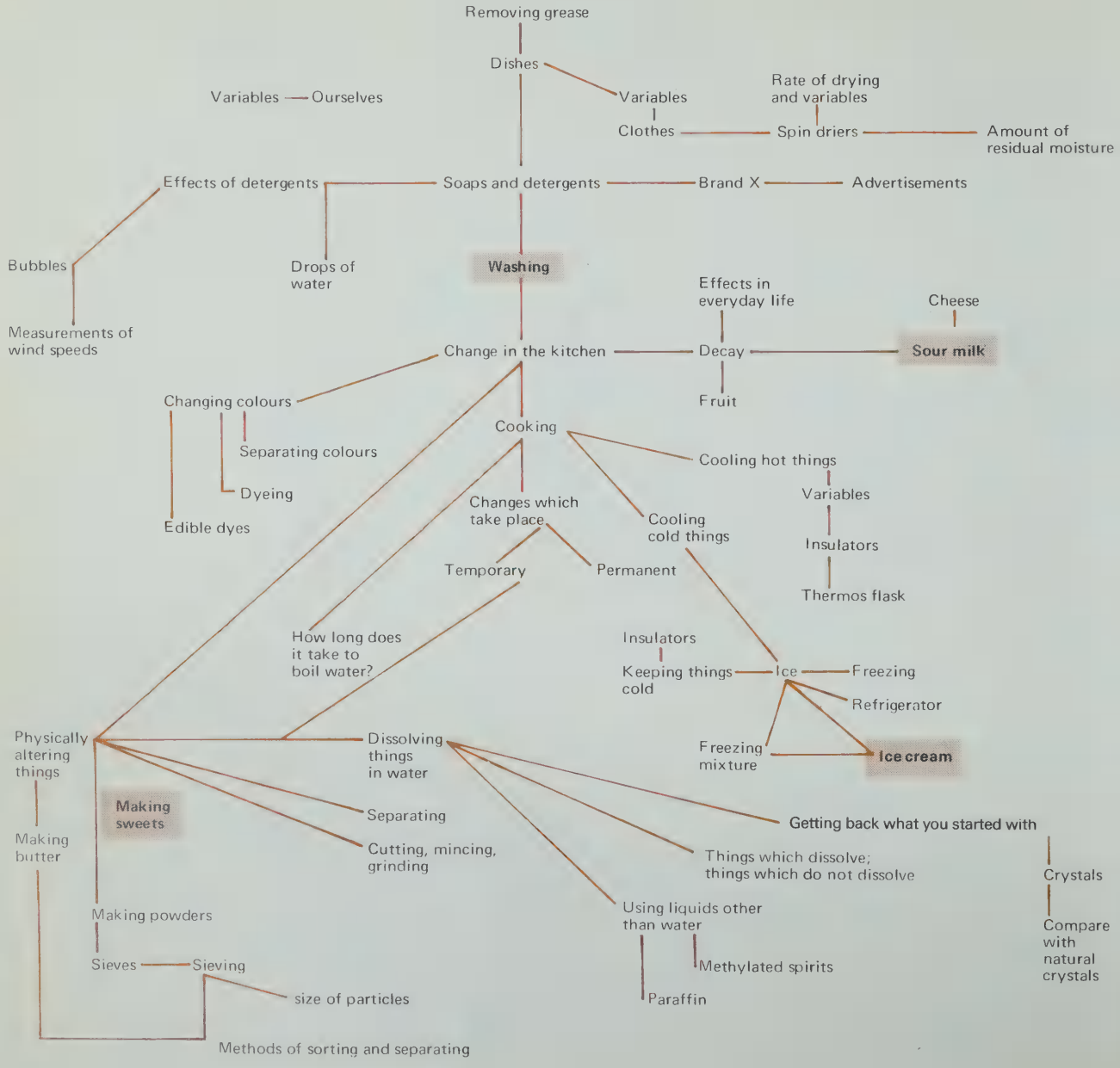
Flow chart D summarises the work of one teacher and her class of children between the ages of nine and ten years.

Flow Chart A

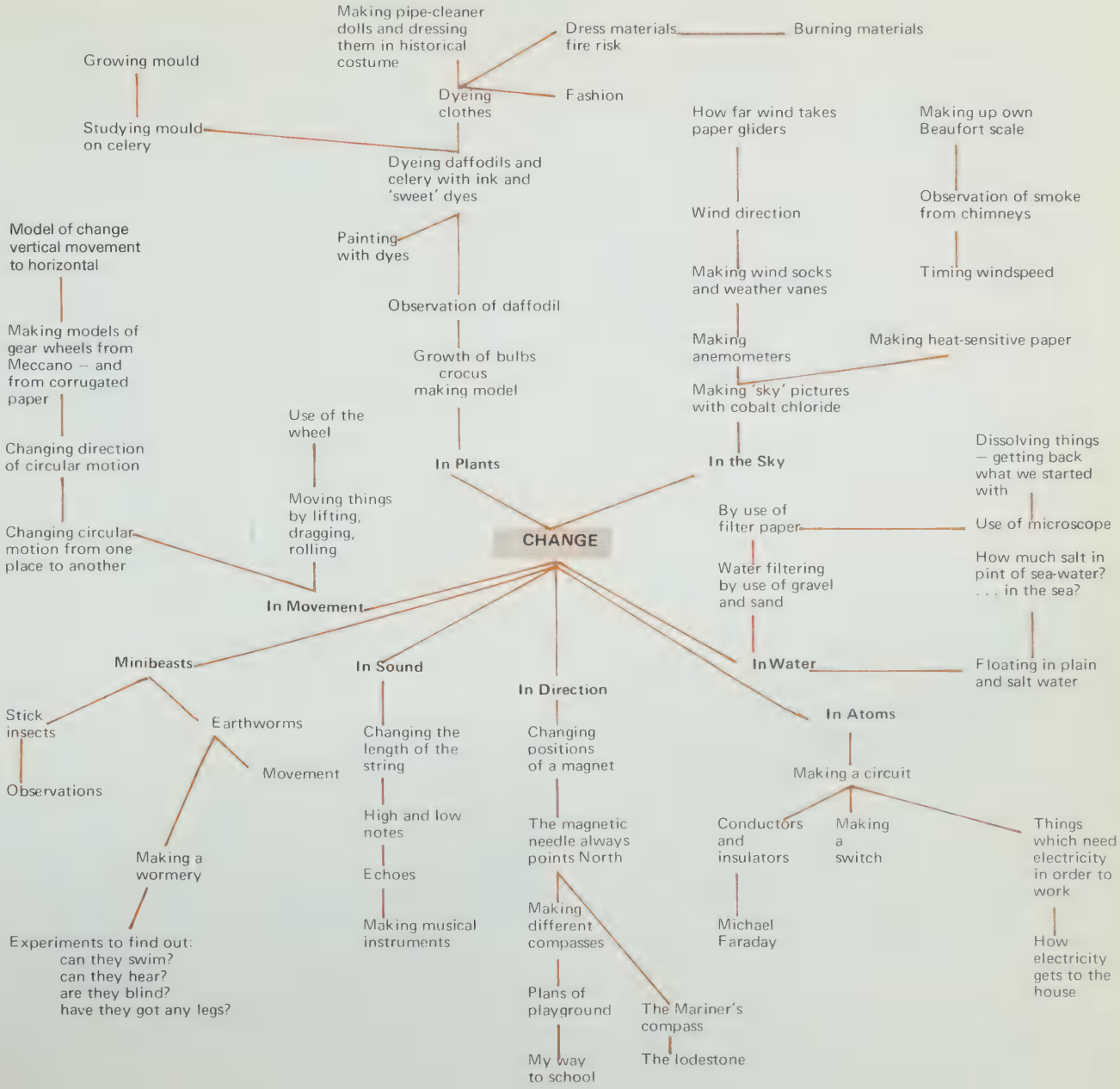

In the playing field
School garden
Local park
What is changing?
Colours
Flowers
Fertilisation
Seeds and Growth
Soil/earth
Digging
Moisture
Effect of frost
What is soil?
Sorting and separating
Particle size
Sand fans
Seasonal changes
Animals
Plants
Conditions for growth
Micro-climates
Weather
Rusting and corrosion
Geological change
Effect of weather
Buildings
Weather sayings
Recording
Contact with schools in other districts to compare records
Starting point

Flow Chart B


Toys
Things which go
Common mechanisms we use and meet
Movement in animals
Movement
Machines
Mechanism
Energy or 'go'
Models
Gears, etc.
Migration
Meccano
Different ways animals have of moving from place to place
Where does the 'go' come from?
Coming to school
Finding our way
Seasons and changing conditions
What forms of 'go' do we meet?
Maps and plans
Transport
Structures and muscles
Three dimensional thinking
Hibernation
Types
History and change
Models
Different types of animals
Life cycle and growth
Pipelines
North Sea gas
Prehistoric animals
Fossils, dinosaurs
Water supplies
Evolution and change
Starting point


Removing grease
Dishes
Variables
Ourselves
Variables
Clothes
Rate of drying and variables
Spin driers
Amount of residual moisture
Effects of detergents
Soaps and detergents
Brand X
Advertisements
Bubbles
Measurements of wind speeds
Drops of water
Washing
Effects in everyday life
Cheese
Change in the kitchen
Decay
Sour milk
Fruit
Changing colours
Separating colours
Dyeing
Edible dyes
Cooking
Cooling hot things
Variables
Insulators
Thermos flask
Changes which take place
Temporary
Permanent
Cooling cold things
How long does it take to boil water?
Insulators
Keeping things cold
Ice
Freezing
Refrigerator
Freezing mixture
Ice cream
Physically altering things
Dissolving things in water
Making sweets
Separating
Cutting, mincing, grinding
Getting back what you started with
Things which dissolve; things which do not dissolve
Crystals
Compare with natural crystals
Making butter
Making powders
Sieves
Sieving
size of particles
Using liquids other than water
Methylated spirits
Paraffin
Methods of sorting and separating

Flow Chart D


CHANGE
In Plants
Growing mould
Studying mould on celery
Making pipe-cleaner dolls and dressing them in historical costume
Dress materials
Burning materials
fire risk
Dyeing clothes
Fashion
Dyeing daffodils and celery with ink and 'sweet' dyes
Painting with dyes
Observation of daffodil
Growth of bulbs
crocus
making model
In the Sky
How far wind takes paper gliders
Wind direction
Making wind socks and weather vanes
Making anemometers
Making heat-sensitive paper
Making 'sky' pictures with cobalt chloride
Making up own Beaufort scale
Observation of smoke from chimneys
Timing windspeed
In Movement
Model of change vertical movement to horizontal
Making models of gear wheels from Meccano – and from corrugated paper
Changing direction of circular motion
Changing circular motion from one place to another
Use of the wheel
Moving things by lifting, dragging, rolling
In Water
By use of filter paper
Water filtering by use of gravel and sand
Dissolving things – getting back what we started with
Use of microscope
How much salt in pint of sea-water? . . . in the sea?
Floating in plain and salt water
Minibeasts
Stick insects
Observations
Earthworms
Movement
Making a wormery
Experiments to find out:
can they swim?
can they hear?
are they blind?
have they got any legs?
In Sound
Changing the length of the string
High and low notes
Echoes
Making musical instruments
In Direction
Changing positions of a magnet
The magnetic needle always points North
Making different compasses
Plans of playground
My way to school
The Mariner's compass
The lodestone
In Atoms
Making a circuit
Conductors and insulators
Michael Faraday
Making a switch
Things which need electricity in order to work
How electricity gets to the house

3 Suggested topics for Stages 1 and 2

3.1 Changes out of doors

3.1.1 Digging the ground

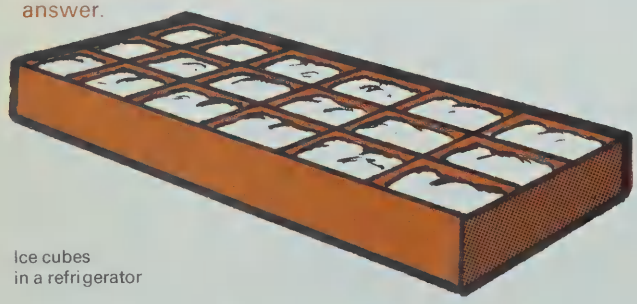
What changes take place when the ground is dug and left ?

Does the soil break up when it dries ?

Why was it said that 'A peck of dust in March is worth a King's ransom' ?

What effect does frost have on the lumps ?

Why ? The following diagram will help to provide an answer.



Ice cubes
in a refrigerator

Consider what happens to the water inside the lumps during frosty weather. 1.27

What change takes place ? 1.57

What is the effect of that change ?

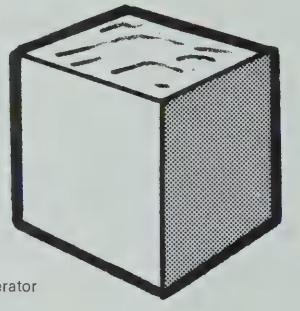
What factors influence the speed of freezing the water ?

An ice cube container is filled with water and then put in the frozen food compartment of a refrigerator. 1.15

What is the shape of the *top* surface of the cubes?

What does this tell you ?

Has the ice expanded ?



Ice cubes
in a refrigerator

3.1.2 Different sizes of particles in soil

Look at a freshly dug border after a rain storm—what changes have taken place ? Has any of the soil been washed into the gulley ? If so, look at the sizes of the particles on top of the border and in the gulley—what do you notice ?

Dark streaks showing the shielding effect of the stones; in quieter water fine dark material has been deposited

Put several spoonsful of soil into a transparent bottle.

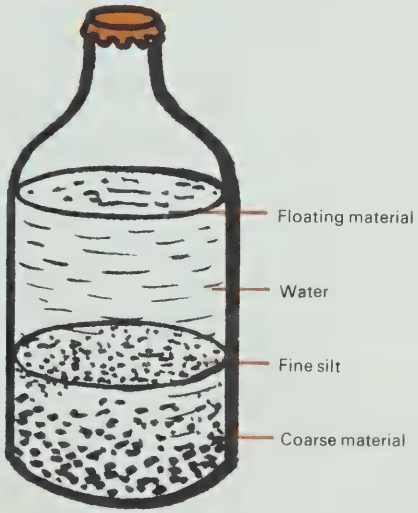
Add some water, stopper the bottle and shake it.

Allow the bottle to stand.

What do you notice about the layers which settle out ? 1.27

Is there anything floating ?

Does the water eventually become clear ?



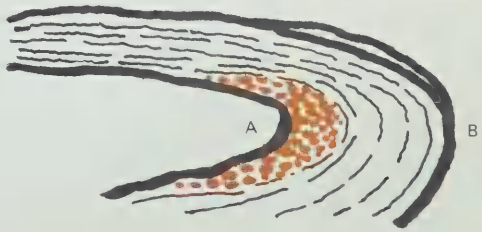
Sedimentation of soil in water

Children often find it monotonous waiting for something to happen so work of this kind could be done at the end of morning or afternoon school.

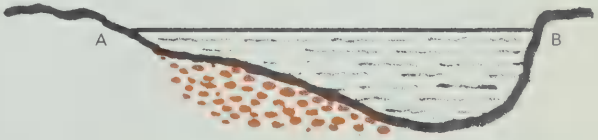
Go out into the playground or on a playing field and look around. Is there any place where the rain has made a small rivulet ? If there is look at the small sand fan; how is it built up ? What can you say about the size of the particles ? Look at them through a hand lens—what are they like ? Collect some and try shaking them with water in a bottle then allowing it to stand. What do you notice ? 2.51

On a larger scale a stream washes away sand and stones from one place and deposits them in another.

Look at a winding stream. The water cuts away the bank *B* and builds up a spit from bank *A*.



The two processes of erosion and deposition go hand in hand.



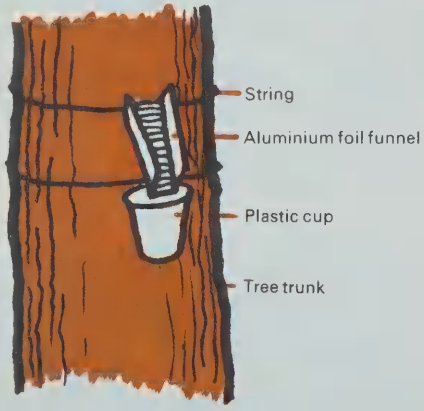
Not only should wearing away and building up be noted but also that the stream tends to sort out the material it carries along. Look for sorting and where it takes place.

Sometimes sand fans can be found in gutters beside paths. Work like this can be tied in with work in geography to provide doorstep examples of much larger processes. A river delta is something like an overgrown sand fan. Small rivulets cause erosion and form gulleys and in severe weather conditions the power of rushing water can be formidable.

3.1.3 Changes due to moisture

Are there any trees in the garden ? Is there any moss or green stuff on the trunk ? If there is which side has the most ? Why ? Is it due to rain ? Which side of the tree receives the most rain ? 1.21 1.43

Devise a method of collecting the water which runs down the trunk, North, South, East, West. 2.41 2.58



Collecting rain running down the trunk of a tree

Are there any damp patches in the garden ? Why are they damp ? When we say the soil is damp, how damp is it ? Weigh a handful of damp soil and then dry it indoors over a radiator and reweigh it. Has a change taken place ? How can the results be expressed ? Are all damp soils equally damp ? Do all soils dry out at the same rate ? Weigh the drying soils at regular intervals and plot the results—try sandy soils, clay soils, loamy soils, black alluvial soils and any you can get. 1.41 2.42

3.1.4 Changes and seeds

Germinating seeds always interest children provided they can see some quick results! Investigations into the changes which take place during germination can be made using mustard and cress seeds in the classroom. What happens if the seeds are kept too dry or too wet, or in the dark or in a box with a hole cut at one end ? Try growing them under different lighting conditions, eg on the window-sill in a dark corner, in a cupboard. 1.81 2.51

How quickly do the seedlings grow ? 2.73

How can we record our observations ? 2.72

One infant class carried out investigations into the factors influencing the growing of mustard and cress and at the end they found out which was the tastiest way of serving up the mustard and cress they had grown—they agreed that mustard and cress on cream crackers was the best !

Don't forget there are lots of other seeds which would do equally well for growing, though perhaps not for eating ! Try acorns, conkers, sycamore flyers, orange, lemon and grapefruit pips, date stones, sweet peas, avocado pear seeds. I have been told that avocado pear seeds can be grown if one end is kept dipped in water—why not try it ?

3.1.5 Changes due to seasons

Spring

Summer

Autumn

Winter

Seasonal changes can be noted, perhaps by taking coloured photographs, mounting them, and then adding a commentary. A diary of garden changes involving plants, animals and weather could be kept and illustrated with drawings and photographs—when is cherry blossom time? 1.22 1.27 1.84 2.81 1.14 2.05

Have you ever grown a carrot garden? Cut the tops off several carrots and plant them in sand in a saucer. Keep the sand moist.

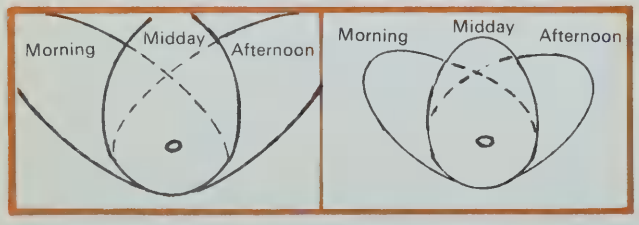
How do the shadows in the school playground change:

Hour by hour?

Day by day?

One spot could be chosen and throughout a day the length of the shadow could be measured and recorded. How does the length of the shadow on a summer's day compare with the length of the shadow on a winter's day?

Plans of the playground could be made showing the shady parts at various times during the day. Or the shading effect of a tree could be compared on a winter's day with the effect on a summer's day. 1.15 1.22 1.77



3.2 Changes due to weather

3.2.1 Weather recording

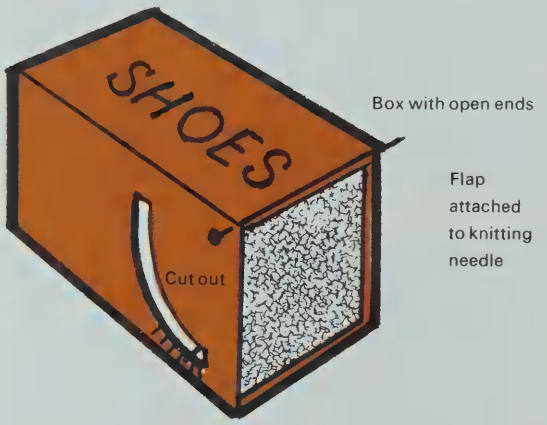
Weather recording is well known and does not require writing about here, however there are several further investigations which are not so often done.

Do all parts of the garden receive the same rainfall? Jam jars set at different places might help to answer this question. 1.41 1.43

How does the smoke from chimneys, perhaps one prominent chimney, rise, blow away in various weathers. A number of ways of expressing the observations can be tried. Besides freehand drawings, cut-out silhouettes can be pasted on sheets and the smoke represented by coloured paper. This suggestion was made by someone who had visited the London Planetarium where a silhouette of the London skyline surrounds the auditorium. 1.15

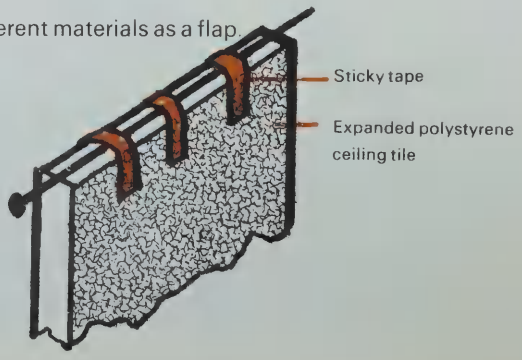
Does wind blow with equal force in all parts of your garden?

Use the instrument illustrated to measure the wind speed (see page 25 for the Beaufort scale). 1.63



There are better models described in the *Solarbo Book of Balsa Models.*

Try different materials as a flap.



Any anemometer needs to be calibrated and a useful devise for this purpose is described in Appendix 1.

One interesting aspect of weather recording has been described by a teacher:

'Apart from normal observation and recording, the main part of the project was communication with two other schools. One of these was directly across the river at a distance of seven to eight miles and the other was inland, also seven to eight miles away, but separated by hills. Daily telephone calls were made between the schools (by pupils themselves) and exchange visits were made. Apart from any Science involved, this arrangement was an outstanding success and it is hoped to continue the relationship established.' 1.22 1.81

3.2.2 Weathering

It will soon be appreciated that weather conditions widely differ over quite a small area. Look at the weathering effects on buildings and rocks. Is there any difference in the amount of grime on old buildings, on say the West side and the East side ? If there is, what caused the grime and what has caused it to be different.

'We were discussing the effects of weathering and pollution on school walls and how it could best be measured. I was thinking of elaborate tests with filter papers when one boy put one hand squarely on the east wall of the school and the other on the west wall facing ICI Wilton. I don't have to tell you which one was the dirtier. Simple but effective.'

Are old stones and bricks in walls worn in any way ? What has caused this change ? Look at old churches for signs of weathering. Has one side of the church weathered more than the others ? Why is that so ?

Are there any outcrops of rock in your district? If there are, find out how they are worn: are there lines of weakness along which weathering is particularly noticeable? Look at the foot of rocky cliffs: are there any fragments broken off the rock? Quite often there is a heap of sharp splinters which have been detached by frost action.

Note the differences in change brought about by frost and rain. This could be the start of work on geological change: consider the action of rain, wind, ice, springs and underground water, streams and rivers, glaciers and sea; these are the factors of geological change. 2.51

Look for geological change around you—valleys, cliffs, hills, scarps, rivers and streams. Look for the two complementary forms of change—breaking down (erosion) and building up (deposition). One cannot take place without the other.

'Cowboy Country': The mesas of Arizona were formed by the weathering of rocks under desert conditions

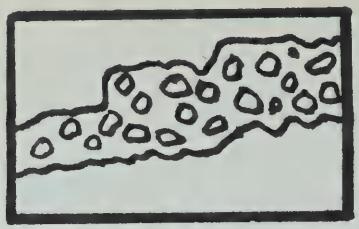
Don't forget that TV can bring shots of other countries into homes and children are probably quite familiar with geological weathering under desert conditions if they did but know it! 1.85

Sometimes if we look at cliffs the evidence of vast changes can be seen. The rocks have been tilted, twisted and folded by giant forces. Other times we may find fossils, those remains of ancient life which so fascinate children. Everywhere there is evidence of change sometimes slow and almost imperceptible, other times showing the power and violence unleashed by natural forces. 1.57 1.44 2.42

Unconformity

Tilting

Folding



Rock composed of boulders

Unconformity

Slates and limestone steeply tilted

Note how the rock composed of boulders rests on a rock which is steeply tilted. The junction between the two series of rock represents a break in deposition covering an unknown length of time. This plane most likely represents an old land surface that was subjected to erosion.

3.2.3 Rust and corrosion

Old cars, tin cans, railings, all rust; all are made of iron in some form. What things rust ? Under what conditions does iron and steel rust ? How can we prevent rusting ?

Information on rusting can be found in *Metals Stages 1 & 2* and *Metals, Background information.*

3.2.4 Weather sayings

Are there any weather sayings in your district ? Collect them, put them into a book and illustrate them. Can you find out if there is any truth in them ? How long would it take you really to decide ?

There are a number of sayings associated with the weather and the cuckoo, eg:

'If the cuckoo lights upon the thorn,
Sell your sheep and keep your corn:
If the cuckoo lands on the blooming hip
Ditch your corn and keep your sheep.' 2.02 2.08

This one depends upon the cuckoo turning up at about the same time each year irrespective of the weather. The bare thorn indicates a 'mean' spring, ie one which is cold and bad for lambing; on the other hand if the wild rose is in bloom, spring is well advanced and the lambing prospects will be good.

Why did the 'common' man use such sayings in the past ? What changes have taken place which make it unnecessary for us to rely on the cuckoo to tell us when spring is here ? 1.82

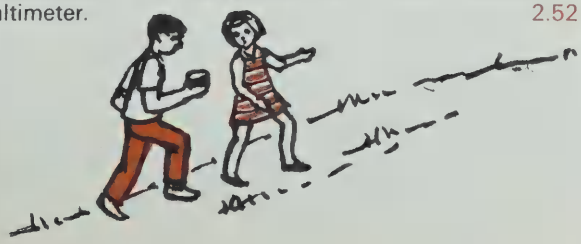
It might be interesting to make a note of the TV weather forecasts and compare them with what actually happens. 1.15

3.3 Micro-climates

A garden has a number of micro-climates, places where the conditions are different from the average conditions, eg under a stone it is likely to be damp and cooler than round about; the ground on the south side of a wall will be warmer and drier than that on the other side of the wall; a wall often has plants growing on the top of it. What are conditions like for these plants ? Look for the micro-climates in a garden and find out what best lives and grows there. Does anything grow on roof tiles or in the gutters ? 1.82 2.51

In a similar way different parts of a town have their climate differences. One school situated on the top of a 450-ft hill compared its rainfall with another school in the valley. They found significant variations in rainfall, wind and temperature, and of course where there are these differences the changes which are dependent upon weather will also differ.

It was interesting to walk up the hill carrying, and making observations with, a small portable barometer. It acted as an altimeter. 2.52



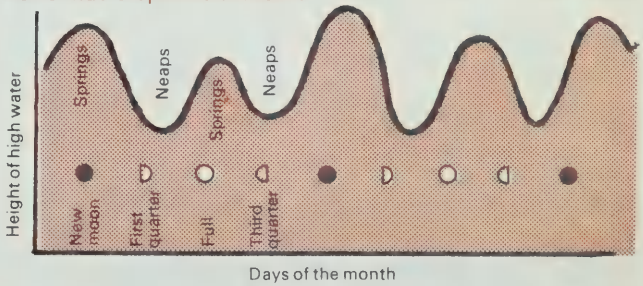
3.4 Changes along the seashore

3.4.1 Tides

One junior school relied on the sands of the seashore for its football pitch—its timetable revolved about the tide-table and the children were well aware of the daily tides and also of the spring and neap tides. They knew how succeeding high tides gradually worked their way through the twenty-four hours and how the neap and spring tides restricted and expanded their playing areas.

Work on tides is easily set going in schools close to the coast but even inland there may be chances for the work to start—a news item of a tanker stranded on a sand-bank, pictures of mud-banks at the mouth of a river, London's third airport, the dykes of Holland: in every case skilful questions can suggest new investigations.

A graph showing tide heights could be made—this would reveal periodic variations. One school found that as a result of plotting figures from a tide table that somehow an error had crept into the table. 1.15 1.71 2.72 2.73



Details of the times and heights of high water for London Bridge, Liverpool, Bristol, Hull, Greenock, Leith and Dún Laoghaire (Kingstown) can be obtained from *Whitaker's Almanack.* Heights of low water are more difficult to find out but possibly can be obtained from the local harbour master.

Children might see the connection between the phases of the moon and the variations in heights of high tides. They may notice that the 'spring tides' after the new moon are generally higher than the 'springs' after a full moon. In this way they may begin to appreciate that in some way the moon causes changes to take place here.

3.4.2 Changes which make a beach

Many children visit the seaside during their holidays. What do they think that the sand is made of ? Where does it come from ? What can we find in a bucket of sand ? 1.27

Shaking some sand in a bottle with water in the same way as for soil (page 13) will show if there is a wide mixture of grain size or whether the sand is largely homogenous in respect of grain size. Does it contain fragments of shell? If present they can be observed using a hand lens. Their possible presence can be investigated by adding vinegar or as a strong solution of citric acid or tartaric acid* to a sample of sand. If shell is present the solution will fizz and the shell will dissolve in the acid giving off the gas, carbon dioxide (the same gas that is dissolved in fizzy lemonade). If there is no fizzing then there is no shell present. 1.57 2.51

Here we make use of change to find out if some of the sand comes from shells. Where does the rest come from ? Are there any pebbles on the beach ? See if you can make a collection:

i. Of different-sized pebbles ranging from sand grain size upwards. 1.65

ii. Of pebbles of different rocks. Try to identify the rocks. 1.76

Sea stacks, Sandy Bay, Devon

Both of these acids are harmless and are used in cooking. Where facilities are available dilute hydrochloric acid is used for testing for carbonates, the material which causes the fizzing when shells are dissolved in an acid.

Not all shores are sandy, some are muddy, some are rocky with rock pools but everywhere change is taking place. Sometimes the sea is wearing away the land and houses and even villages are washed away.* Sometimes the sea is receding and beaches are left high and dry. What changes can you spot ?

Old sea cliffs

Former beach, now grass

The Maer at Exmouth, an example of a raised beach

3.4.3 Changes from fresh water to salty

The mouths of rivers often contain mud flats – why ? Why is mud deposited just there ? Is it something to do with salt water ? Take some mud, shake one lot with tap water, the other with salt water. Allow to stand. Which settles quickest ? 2.51

Mudflats and marshes at the mouth of the River Otter, Devon

The advance of the sea is often due to the slow sinking of the land or a rise in sea level. A recession of the sea may be due to a deposition building up land, eg mud flats, a fall in the sea level or a rise in the land surface.

Sea water is salty, can we get the salt out of the water? What happens if salt water is left to evaporate in a shallow dish? How much salt does sea water contain? How can we find out and measure it?

Have you ever swum in sea water? Did you float better in one than in the other? Which one? If you were to swim down a river and out into the sea what changes would you notice? (Do *not* do this – it is dangerous.)

Samuel Plimsoll, the sailor's friend

Ships float higher in salt water than in fresh water—how could we show this in the classroom?

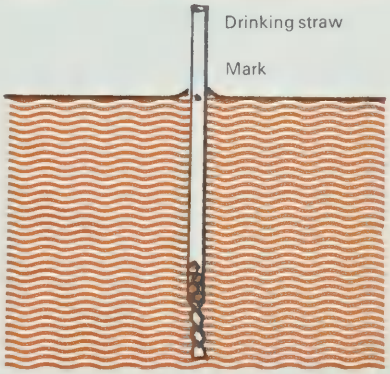
Take a drinking straw, seal up one end and drop lead shot inside until the straw floats upright when put into water. 2.11

Make a mark with a waterproof felt pen showing the water line when floating in tap water.

Float the straw in sea water. Is the mark now out or under the water? 2.56

Now make up a solution of salt in water and float the straw in it. Is the mark above or below the level of water?

Add some more salt (remove the straw first), stir until dissolved and now test with the straw. What happens?



*Lead shot added until the straw floats upright in the water

Screwed up end dipped into molten candle wax or sealing wax

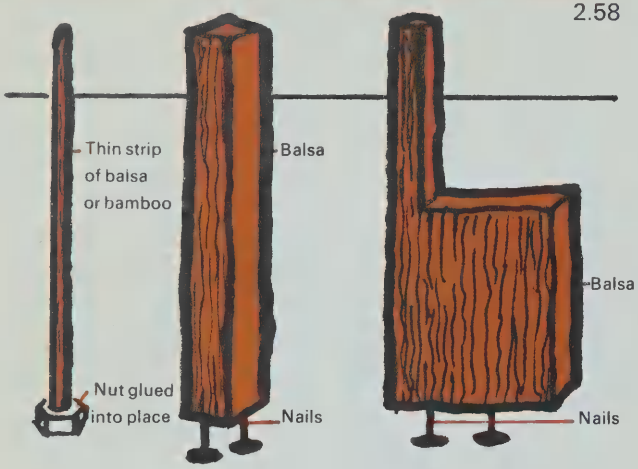
Can the height of the mark above the water be related in any way with the amount of salt used? In other words is the *change* in the amount of straw out of the water related to the *change* in the saltiness of the water? Could this method be used for finding out how much salt is dissolved in say a milk bottle of sea water? 2.32

**Sources of supplies of lead shot: fishing-tackle shops; physics or chemistry departments of secondary schools; gunsmiths; Teachers' Centre; BDH; chemical and apparatus supply houses; sometimes local chemists can order a quantity from their supply houses.*

If lead shot is not available, try cutting up old balsa cement tubes. These are made of lead.

Other weighting material: try small nails, panel pins, brass sprigs.

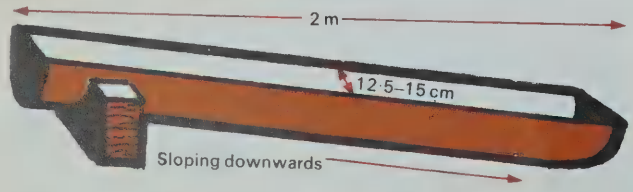
Besides making hydrometers from drinking straws they can also be made from balsa. The following diagrams show some of the designs which have been tried. Which one is the most sensitive to small changes in salt concentration ? 2.58



Make sure that any balsa wood is varnished with aeroplane dope (from the local model shop) before it is dipped into water otherwise the wood will absorb water and lose buoyancy.

3.4.4 Changing waves

Do waves of the sea change from day to day ? What kinds of waves can you observe ? What factors alter the size, shape and speed of waves ? Why do waves break ? From which direction do waves come into the shore ? Do they always come from the same direction ? Does the direction of the wind have any effect on the waves ? Can you find out anything about waves using a piece of plastic guttering as shown in the diagram ? 1.29a 1.15 1.27 2.46



Make a wave at the 'deep end' by 'pushing' the water along with a piece of wood. Does the wave change shape as it moves along ? How fast does it move ? How could you find out ? 1.36

Look for sea defences, breakwaters, harbour walls, what shapes are they ? How are they built ? How do they act ? What was Mulberry Harbour ? How was it constructed ?

Are there any groynes along the shore ? What do they do ? Look at the levels of the sand on either side of the groyne—what does this tell you ? What is changing ? What is the cause ? 1.81

Beach groyne, Exmouth, Devon

3.4.5 Changing patterns of ships

Ships come and go—where do they come from, and where do they go to ? What do they carry ? What different shapes can you see ?

Even if you live inland the TV brings pictures of ships to

Fishing boats with registration marks, Whitby, Yorkshire

nearly every home. Some event could very well start work involving boats and ships. Often there is talk of super tankers. How big are they? Is it possible in any way to bring home just how big they really are or must 250,000 tons and 1100 ft long remain just a set of incomprehensible figures?

Is there a fishing boat registration harbour near you ? If there is, what are its letters of registration ? Do the fishermen fish all the year ? What do they catch ? Do they change their fishing grounds or their prey at different times of the year ? Has the fishing industry altered in the last thirty years ? If so, how ?

3.5 Changes in the sky

There are quite a number of topics associated with the sky, the sun, moon, stars, clouds, winds, aeroplanes, birds, bats and insects. Some of these could be investigated in connection with 'change'.

3.5.1 Sun, moon and stars

A sequence of work dealing with the changing position of the sun, moon and stars in the sky has been dealt with in the Project's book, *Time.*

3.5.2 The changing patterns of the clouds

The shapes and patterns of clouds in relation to the time of the year, the weather and even the position of the local hills might be investigated. The subject could well arise as the result of an aeroplane journey during the holidays. 1.22 1.15

Above the clouds

How many children in your class have been abroad for their holidays ? How many have travelled by air ?

A flight above the clouds reveals patterns which are unlikely to be appreciated from the ground. This could well be just the stimulus to answer such questions as:

What are the shapes of different clouds ?

Are certain types of cloud associated with a particular type of weather ?

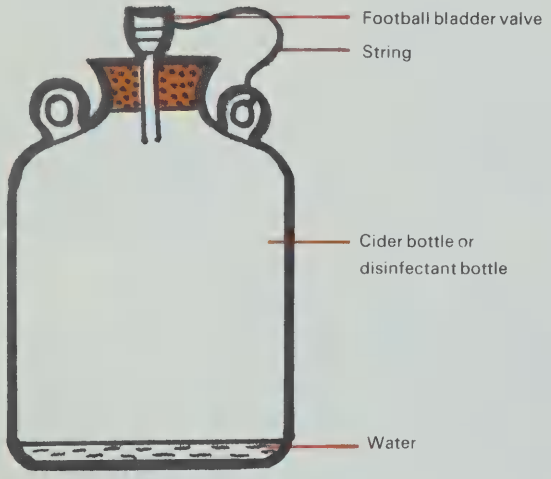
Do you find certain types of cloud at certain heights ?

Are certain clouds really black ?

What is the shape of thunder clouds ?

As well as drawing clouds an attempt might be made to make typical clouds out of cotton wool, suspend them in a box and even add some form of lighting. 2.26 1.77

How are clouds formed ? The simple answer is that moist air when it rises cools as the result of expansion. This cooling causes the moisture to condense in the form of small droplets so forming clouds. There is a delightfully elegant way of showing this on a small scale but as it is a demonstration method teachers may feel that it would be inappropriate for their children. However a method is given in the following diagram. 2.46



Make sure that the cork is firmly pushed home, then use a bicycle pump and pump about thirty strokes of air into the bottle.

Disconnect the pump and connector and loosen the cork so that it pops out.

(The string is to prevent the cork from flying out and hitting someone.)

What is seen inside the bottle ?

When a gas is compressed it gets warmer, when a gas expands it gets cooler. If air which is saturated with water vapour is cooled a mist tends to form if there are particles on which droplets can condense. If a cloud does not form blow some smoke from a piece of smouldering brown paper into the jar then pump away. 2.51

3.6 The winds of change

'The North Wind will blow
And we shall have snow . . . '

Do we ? What are our chances of getting snow if the wind is from the north ? How does it vary with the time of the year ? 2.08

Or

'The West Wind brings us rain,
The East Wind blows it back again.'

Do they ?

Have you any local sayings about the winds ?

Are they generally true ?

When the wind changes, does the weather change ?

Winds blow dust, leaves, paper, trees and in hurricanes even houses are blown away. In 1805 Sir Francis Beaufort devised a scale for recording the strength of the wind. Originally it was used by sailors but it has been adopted for recording the strength of wind over land.

Note that the wind force is recognised by the changes which are produced and that energy is required to bring about these changes. 2.52 2.53

By using the anemometer shown on page 16 construct your own wind-speed table.

How can you tell from which direction the wind blows ? (Damp finger, pieces of grass, soap bubbles, smoke, weather-cocks.) Are there any weather-cocks near you ?

For example: 1.28

A galleon—Poulton-le-Fylde Church.

Sometimes these are quite unusual:

Father Time—Lord's Cricket Ground.

A hunt in full cry—Langdale, opposite the New Dungeon Ghyll Hotel.

What about designing one for your school ? Besides design there are a number of practical problems to be solved: 1.92

What should it be made of ?

Corrosion and rust problems.

Bearings

Balance of weight.

The position of the centre of lateral area.

Where should the weather-cock be located ?

3.6.1 The Beaufort scale for wind speeds and forces

No.	Description of wind force	Wind speed in m/h	Changes or how the wind force can be recognised from common signs
0	Calm	0–1	Smoke rises vertically
1	Light air	2–3	Smoke slowly drifts
2	Light breeze	4–7	Wind felt, leaves gently rustle
3	Gentle breeze	8–11	Leaves in continuous movement, flags flap
4	Moderate breeze	12–16	Dust and paper blown about, small branches in motion
5	Fresh breeze	17–21	Small trees in leaf sway
6	Strong breeze	22–27	Branches in motion, whistling in telephone wires
7	Moderate gale	28–33	Whole trees sway
8	Fresh gale	34–40	Twigs and small branches broken off trees
9	Strong gale	41–48	Large branches broken off, slight structural damage to houses
10	Whole gale	49–56	Trees uprooted, roof damage
11	Storm	57–65	Seldom experienced inland—if it is,
12	Hurricane	+65	look out !

3.6.2 Making use of wind

Are there any old windmills in your district ? When were they built ? What did they grind ? If you can, find out about the cogs and gears and how the power was led from one place to another. 1.58 2.52

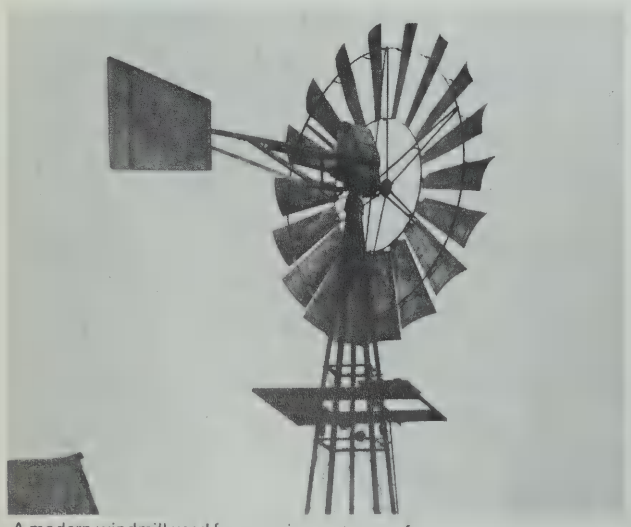
An old windmill, Morgan Lewis, Barbados. Windmills such as these were used for crushing sugar cane

What are the millstones made of?

Look at the old maps in the local library or museum for sites of mills and farms. Do any local farms use windmills to pump water ? How does the pump work ? Why not make a model of a windmill or even make a simple working model powered by the wind ? 1.77

Seldom do we directly make use of the 'power' of the wind—we have to change it; make the wind blow the boat in the direction we want it to go, to harness the wind power to turn a windmill. In these examples we have caused change to take place and by doing this we have made wind do useful work. As the result of change, energy (in some form) has been obtained.

A square - rigged sailing ship

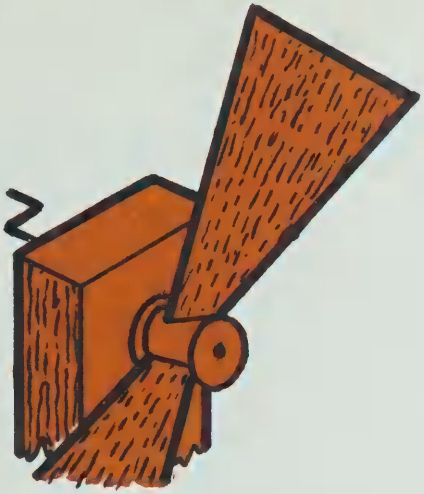


A modern windmill used for pumping water on a farm

Land yachts. These ungainly vehicles can travel faster than the wind itself

3.6.3 Simple toys powered by the wind

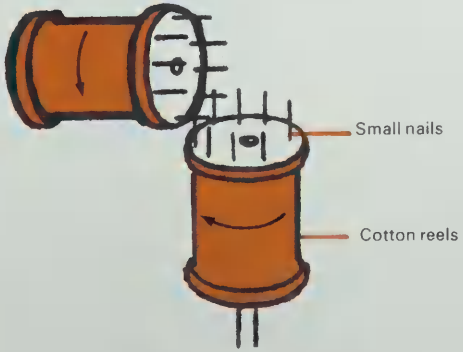
Toy windmill



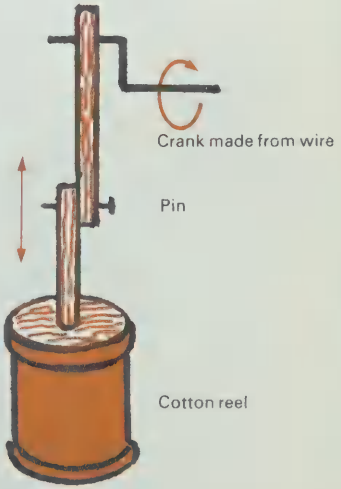
Dancing doll

Made from flat balsa wood strung together with string and painted

Simple gears as used in old mills



Model of a water pump



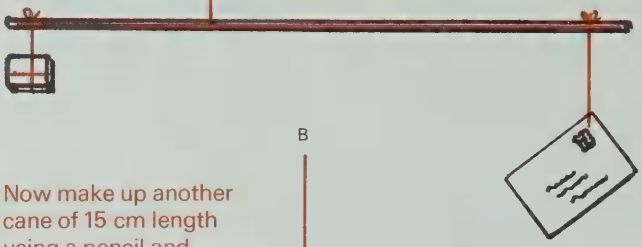
3.6.4 Let us make a mobile

A successful mobile is one which is well balanced and moves in a light breeze. The first thing is to appreciate the principle of balancing; take a light piece of cane about 25 cm long, at one end hang a rubber, at the other end a postcard.

In place of a piece of thin bamboo cane, balsa wood $\frac{1}{8}$ in $\times$ $\frac{1}{8}$ in [approx. 3 mm $\times$ 3 mm] is very suitable.

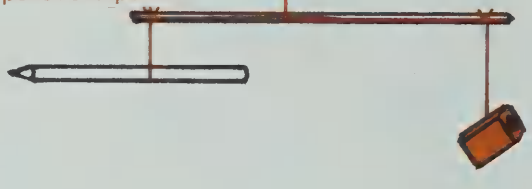
1.28 1.33 1.34

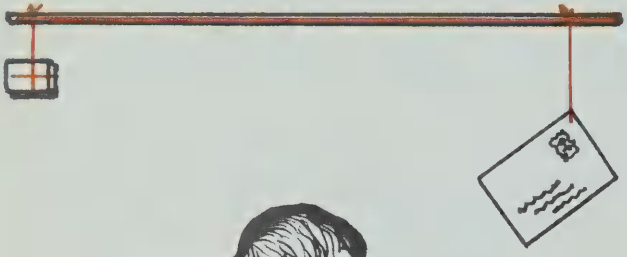
A Find a point on the cane where the whole lot will balance and tie a piece of cotton to the cane so that it can be suspended still in balance.



B

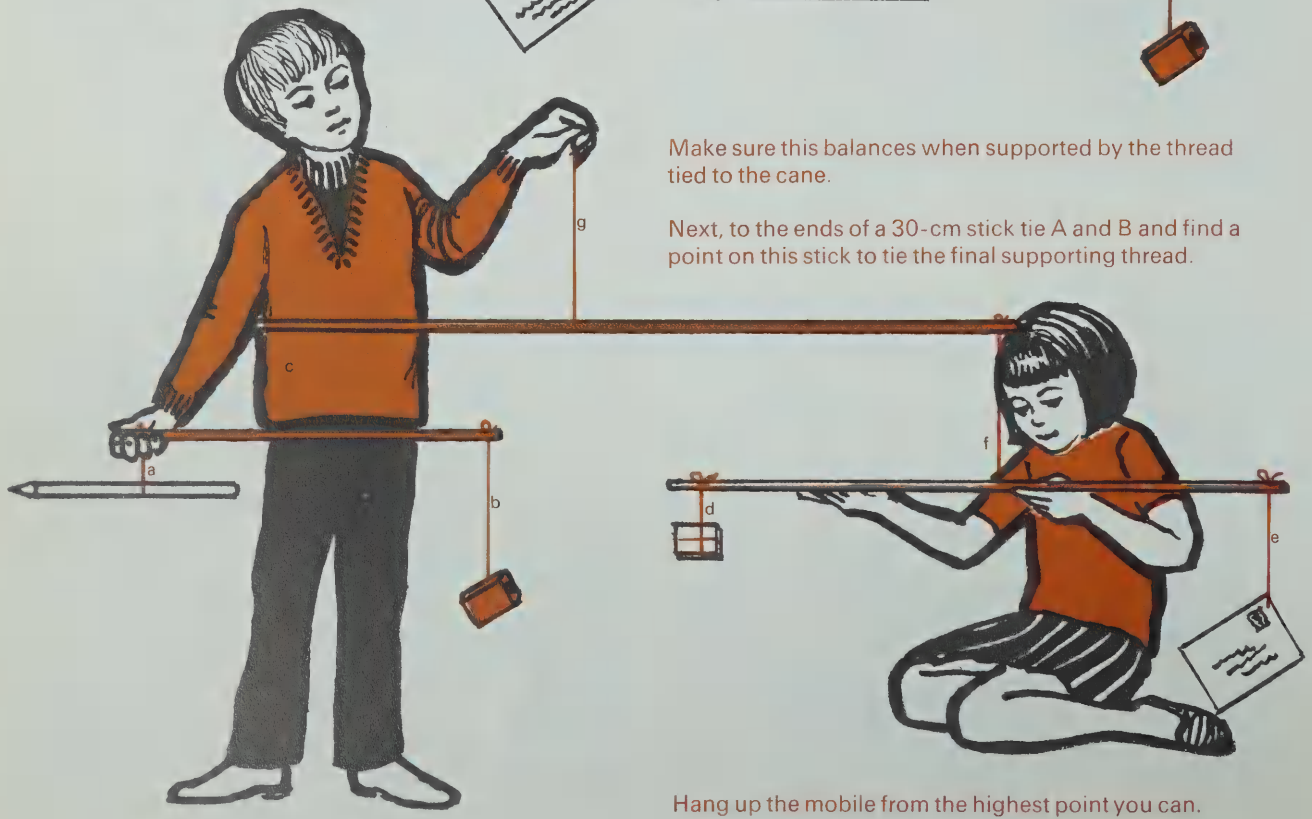
Now make up another cane of 15 cm length using a pencil and a pencil sharpener.



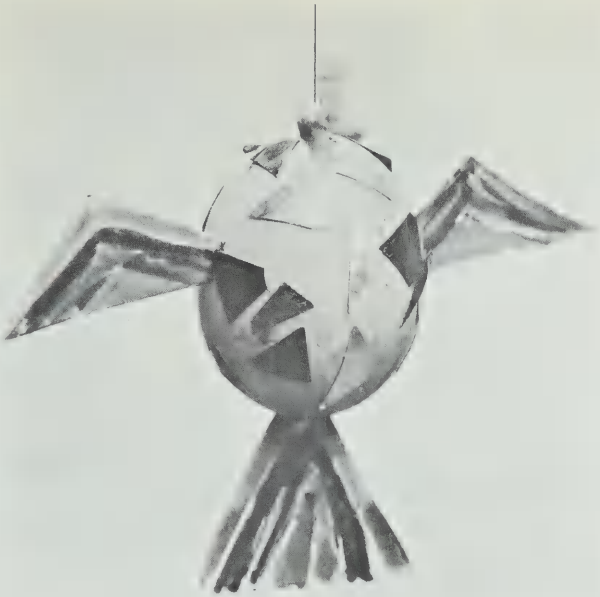


Make sure this balances when supported by the thread tied to the cane.

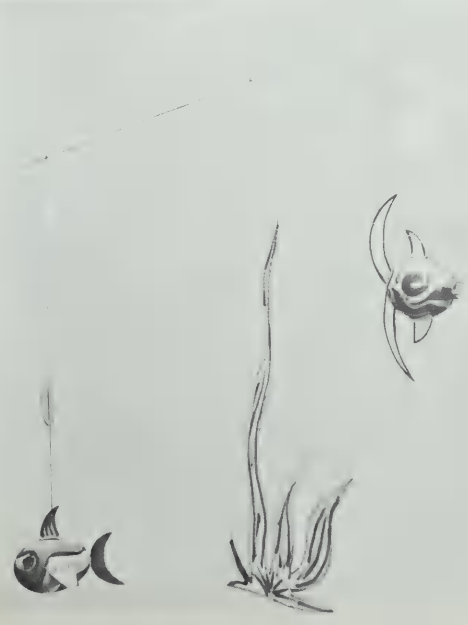
Next, to the ends of a 30-cm stick tie A and B and find a point on this stick to tie the final supporting thread.



Hang up the mobile from the highest point you can.



Mobiles made from blown eggs

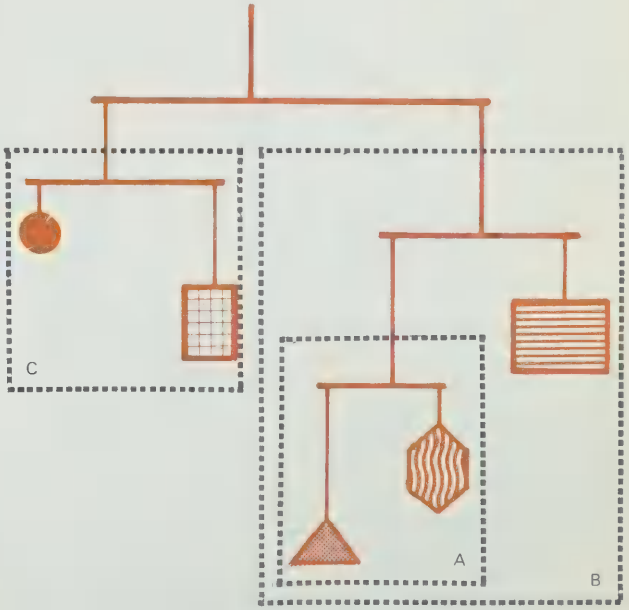


Try:

Different lengths of cane.
Different lengths of supports (a, b, c, d, e, f, g,).
Different weights of motifs.
Different areas of motifs. 1.63 1.58 2.42

A well-made mobile is always changing and the paths of the various objects can be very complicated.

A more complicated mobile



This mobile is made up of a number of balancing systems.

First there is A then B.

Next there is system C, for a moment isolated from A and B. Finally system C is made to balance (A and B).

Remember balancing is carried out by altering the position of the supporting thread, not by altering weights.

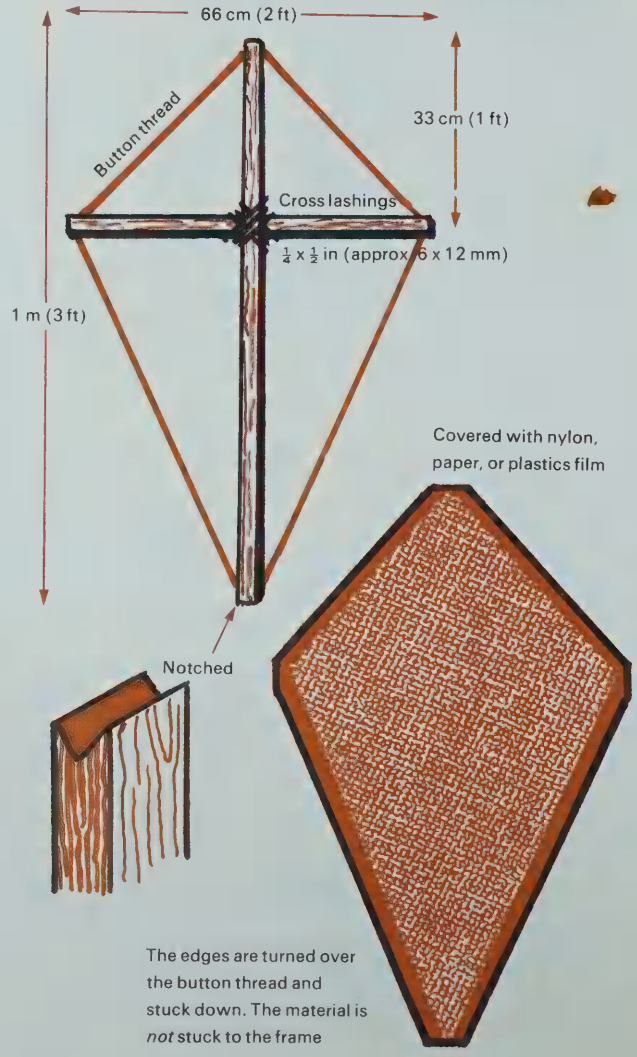
3.6.5 Let us make a kite

In the past boats were propelled by the wind—children (and grown-ups) are fascinated by boats and some suggestions for activities can be found in *Science from toys.* Another toy which depends on the wind is the kite. How many children in your class have or have flown a kite ?

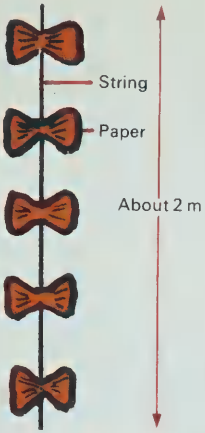
Kites are fairly easy to make and details of a number of simple models can be found in the *Solarbo Book of Balsa Models.*

The following details cover the construction of a traditional flat kite.

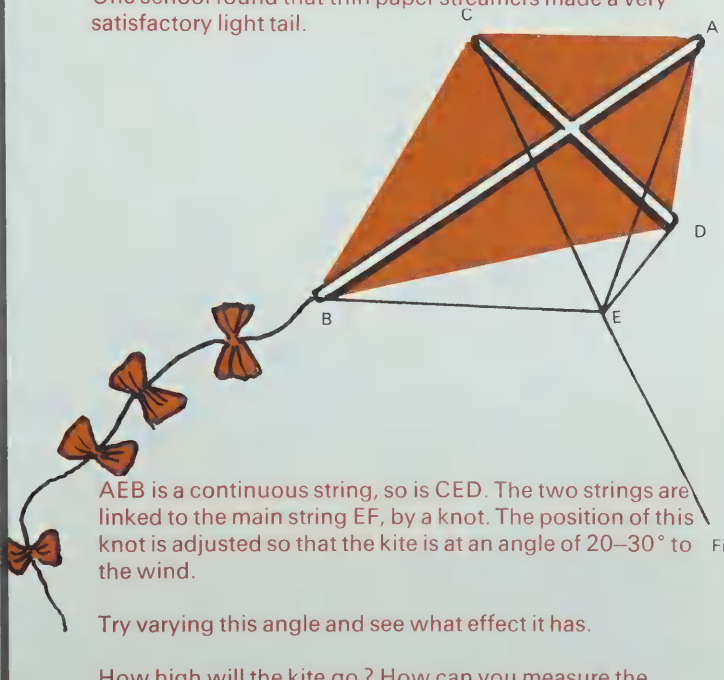
Materials: $\frac{1}{4} \times \frac{1}{2}$ in (approx. 6 x 12 mm) obeche from local model shop, or a thin bamboo cane; button thread; thin paper, nylon, or thin plastics film; string or fishing line


66 cm (2 ft)
33 cm (1 ft)
Button thread
Cross lashings
$\frac{1}{4} \times \frac{1}{2}$ in (approx. 6 x 12 mm)
1 m (3 ft)
Notched
Covered with nylon, paper, or plastics film
The edges are turned over the button thread and stuck down. The material is *not* stuck to the frame

Flat kites are sensitive to the amount of tail they carry and it may be necessary to try different lengths.



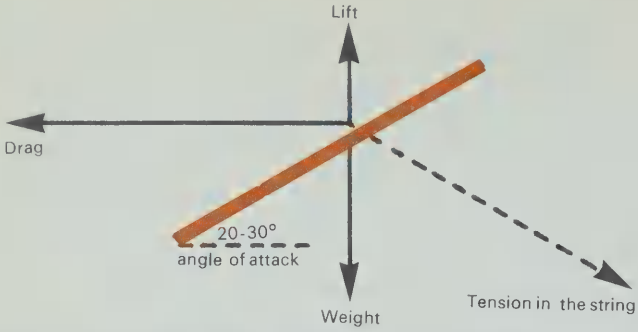
One school found that thin paper streamers made a very satisfactory light tail.



AEB is a continuous string, so is CED. The two strings are linked to the main string EF, by a knot. The position of this knot is adjusted so that the kite is at an angle of 20–30° to the wind.

Try varying this angle and see what effect it has.

How high will the kite go ? How can you measure the height ?
What weight will the kite carry ?
Where must the weight be fastened ?



The forces on a kite. A simplified version–background for teachers

Note should be paid to the following safety precautions:

Do not fly a kite in a thunderstorm (in spite of Benjamin Franklin).

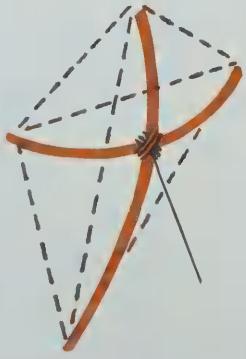
Do not fly a kite near power lines.

Do not fly a kite near an aerodrome.

Do not fly a kite so high that it may interfere with aircraft.

Do not use wire as a line.

A useful class discussion could be held to probe the whys and wherefores.



Another form of kite is the curved type. These resemble saucers flying with the convex side towards the wind.

They are made by lashing two bows together.

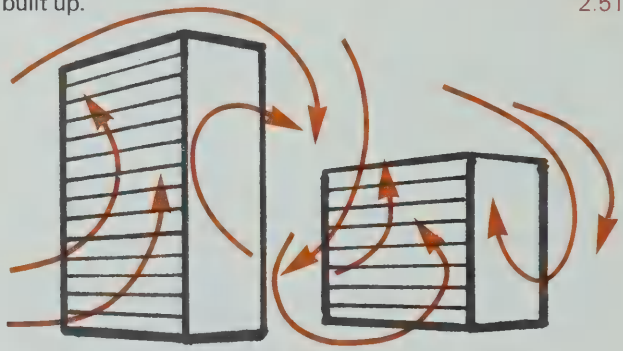
Then covering the convex surface with thin tissue paper.

The string is fastened to the cross.

These kites are supposed to fly without the use of tails.

3.6.6 Changes brought about by wind

Some of the common effects of wind are listed in the table on page 25 but if a child flies a kite he will soon realise that there is a lot of difference between the turbulent air around buildings and the almost constant wind higher up. What causes this turbulence? To investigate the flow of air over and around buildings the anemometer described on page 16 could be used and this together with observation of leaves, dust, bubbles and pieces of paper might provide sufficient information for a picture to be built up. 2.51



Turbulence around buildings–windy corners

The local effect of a gale could be a starting point for this topic. Every year rows of beans and their supporting canes are blown down. What effects do winds have in the countryside ? 1.27

Look for:

Trees leaning with the prevailing wind.
Dust clouds in springtime.
The effects of hedges and copses.
Trees planted as wind breaks.
Places where leaves or pieces of paper collect. 1.82

What do birds do when there is a high wind ?

Do high winds or a constant wind influence the shape or pattern of things ? Are your local bus shelters well designed ?

What is the effect on sand on a beach ?

How do dunes form ? Have they a particular shape ? Do they move ?

How can they be stabilised, ie prevented from moving ?

In Cornwall there are stories of churches buried beneath the sands—are there any dunes near you ? 1.28

What are snow fences ? How do they work ? The next time it snows see how the fallen snow piles up. Prepare a plan of the school playground and mark in where the snow collects—don't forget to include the direction of the wind.

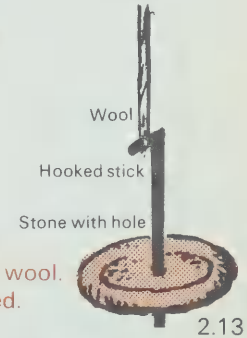
Make a cardboard model of the school grounds and playground; then use it together with an electric fan and some fine powder to see whether the powder piles up similar to the real thing. Carry out the investigation outside and try as powders, flour, plaster of Paris, fine sand. 1.77 2.74

3.7 Changes in clothes

3.7.1 Clothes in history

As a start quite a lot can be done by dressing pipe-cleaner dolls in historical costumes made by the children. Changes in fashions can be traced quite easily by this method which can be used to display the clothes of other countries. Work might diverge into considering how cloth is made, how threads are spun and dyed. Perhaps some children might try to spin their own thread from wool collected from hedges. 1.62 1.05

A primitive way of spinning threads.



The stone is spun and this twists the wool. Wool is added as the stone is lowered. 2.13

Most schools have found that the task is beyond them: the techniques may be primitive but the difficulty shows that prehistoric man achieved a level of attainment not usually appreciated.

Spinning by distaff and spindle, early 14th century

3.7.2 Colours

It is the blending and contrasting of colours which appeals or repels; which colours can be paired (painted next to each other) to form:

likes ?/dislikes ?

The colours change the material in the eyes of the beholder but how does the material come to be coloured ? Here children can start with simple cold-water dyes, follow the instructions on the containers and dye pieces of cloth. 1.57

Let them try different materials—using the same solution and keep the different materials in the liquid for the same time. Are the pieces of cloth dyed the same colour ? Most likely they will find that a piece of nylon will turn a different colour to a piece of cotton material. Get them to mount the pieces on a sheet of display paper and describe what they have done. Here they are attempting to make comparisons in terms of one property or variable. 1.59 1.14

The dyeing of material involves a number of variables. Some of them are:

Type of material

Not all materials can be dyed with the same dye. The packets of dye which can be purchased in shops contain a number of dyes so that they will dye a variety of materials. However there may be variations in the colour that is obtained.

Concentration of the dye bath

Make up baths of different concentrations one very much weaker than recommended and one which is the suggested strength. Dye pieces of the same material for the same length of time. Is there a difference in colour ?

The length of time the cloth is left in the bath

Using the same material and the same concentration of dye, try leaving the cloth for different times in the dye liquid. Again are there variations in colour ?

So a progression has been made from considering one variable to an awareness that more than one variable may be involved in a particular change and that there is a need to control variables. 1.42 1.44 2.43

Natural dyes can be prepared by boiling in water the following:

Blackberry, elderberry, blueberry (whortleberry/ bilberries/winberries)	*Reds if citric acid is added (only a pinch).*
Pickling cabbage	*Blues if borax/soda is used (only a pinch).*
Onion skins	*Yellow.*
Mosses, lichens	*Greens and yellow-green.*
Log-wood chips	*Yellow, green, purple depends on acid/alkalinity.*
Oak apples (galls)	*Dip cloth in a solution of the gall and then into iron II sulphate solutions. The cloth darkens on drying.*

Rolf Hartung, Colour and Texture in Creative Textile Craft, *B. T. Batsford Ltd, 1965.*

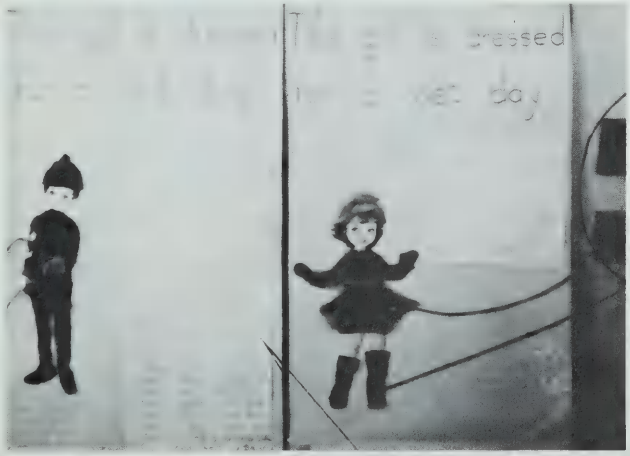
Boil in the minimum amount of water then strain through a piece of clean old handkerchief. To dye, dip the material into the boiling dye extract.

Try strands of white wool or strips of white cotton material.

Use the dyed material to make something, a school flag maybe. This might well be the starting point or motivation for investigating dyeing.

3.7.3 Clothes and climate

As a result of considering clothes in other countries, clothes in relation to the weather could be investigated. What clothes are worn when it rains ? Carry out a class survey—how many children wear raincoats or anoraks ? What clothes are worn on a hot summer's day ? What clothes are worn on a cold winter's day ? How do they differ ? How do clothes keep you warm ? What clothes should you wear and carry with you when you go walking on the Fells ? This is an important issue and should be probed so that children understand why certain precautions are essential and it is not being grown-up or big to take unnecessary risks. 1.92 2.03



To show how clothes prevent loss of body heat squeezy bottles containing hot water and a thermometer can be wrapped in various 'coats' and the temperature recorded at regular intervals. Display the results in some suitable graphical form. Which covering acts as the best 'coat' ? One function of clothes is to prevent changes from taking place—what are these changes ? List them. 1.59 2.72 2.73

There are many other ways in which clothes and climate could arise but generally a start which is immediately related to children say by comparing themselves with other children, is more likely to have an impact than one which is treated as an academic exercise.

3.7.4 Safety first

Far too often children are burnt through clothes catching fire and one topic which ought to be studied is clothes and fire risks. Get children to make a collection of different fabrics both of different textures and of different materials.

Quite likely their mothers would help in providing named fabrics.
As a rough guide:

Stockings	— nylon
Handkerchiefs	— cotton
Suiting patterns	— wool and wool mixtures
Dresses and blouses	— these are often labelled with the name of the fabric.
Net curtains	— Terylene or nylon

Try materials such as:

Flannelette	— often cotton
Winceyette	— cotton or rayon or mixture
Viyella	— wool
Knitting wool	— is usually marked if it is a mixture

Let children carry out a standard test which they can devise themselves to see if the material will burn on its own, by simply lighting it, or only when there is a flame applied all the time. 2.43 1.41

If it does burn does anything drop off ? eg burning blobs of sticky stuff.

Does it burn slowly or fast ?

Is anything left behind after burning ?

Is there a distinctive smell when burning ?

Any work involving flame and/or burners needs careful supervision and the opportunity might be taken to talk about safety in the home and accidents in general.

Certainly the results will make the children aware of the fire risks of some materials.

In the classroom a bucket of sand and a squeezy bottle full of water would be a sensible precaution.

It is suggested that the investigations be carried out over a sheet of asbestos, holding the pieces of material in a wooden clothes peg (plastic ones are much more liable to melt and burn) and using a candle as a source of flame.

Pieces of the partly burnt cloth can be mounted on sheets with children's notes attached. 1.42 1.43 1.59

One school used 5 × 30 cm strips of material, marked a line 10 cm from one end and held the strips by means of a wooden clothes peg. The time taken to burn 10 cm was measured:

Flannelette	3 seconds
Cotton twill	5 seconds
Fine cotton	5 seconds
Terylene net	5 seconds
Rayon	6 seconds
Lurex	7 seconds
Crepe	7 seconds
Fur fabric	10 seconds
Velvet	12.5 seconds
Nylon stocking	14 seconds
Wool	15 seconds
Nylon net	24 seconds

It might be possible to try to fireproof some pieces of material—using a strong solution of borax in water. Another fireproofing solution is to make up two solutions, one of microcosmic salt (ammonium sodium phosphate, which can be bought from a chemist) in water, the other of Epsom salts in water. Soak the cloth first in one solution, allow it to dry then dip into the other solution, remove immediately and allow to dry. Suitable concentrations would be a tablespoonful in a pint of water. Try the treated and untreated cloths together and see if there has been any improvement in the fire resistance. 2.51

Sources of information about man-made fibres:

1. British Man-Made Fibres Federation, Bridgewater House, 58 Whitworth Street, Manchester, M1 6LS

The BMMFF issues a very useful booklet, *Facts about Man-Made Fibres,* which gives information about properties, uses and washing of materials made from these fibres.

2. Courtaulds Ltd, Public Relations Department Education Service, 18 Hanover Square, London, W1A 2BB.

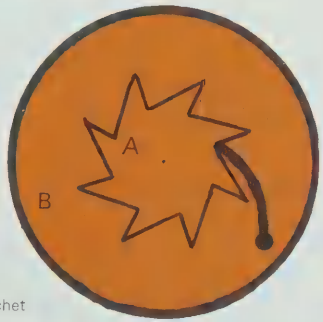
Courtaulds provide named samples of materials together with information on the development of man-made fibres.

3.8 Changes in movement

Besides changes of movement involving position, ie moving from one place to another, we could consider changes of movement involving gears, cranks and levers. We now enter the fascinating world of mechanisms, a topic which intrigued the toy makers of the eighteenth and nineteenth centuries. They produced the complicated automatons which mimicked man. 1.28

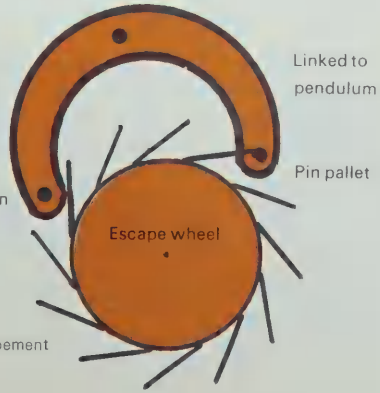
The mechanism of a clock provides a host of examples of gears and gearing—if one gear wheel makes one turn how much of a turn does another wheel make ? How does the escapement of a clock work ? What keeps the clock or watch ticking at a fixed rate ? 1.29a 1.81

If A moves ↻ it turns B as well. 2.52



Winding ratchet

If A moves ↺ the pawl does not engage with the gear teeth but slips over them thus B remains stationary (see *Time*).



Clock escapement

How does the ratchet on the winding mechanism work ? Don't do it but what would happen if you made the ratchet slip ?

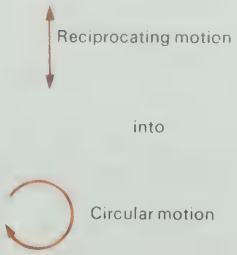
Look at a mechanical toy. How does it obtain its energy ? Is there a spring ? What is it made of ? Is there a winding ratchet or is there a simpler system ? What does the gearing do ? For one turn of the winding handle how many times round does the final drive go ? Sometimes there is a regulator to stop the final drive going too fast—how does it work ?

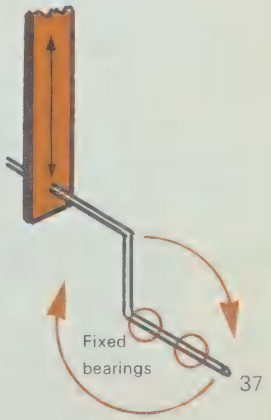
Sometimes it is necessary to make the line of power turn through a small angle as for example in a motor car the engine is connected to the back axle by means of a universal joint. In a model boat the engine is often connected to the propeller by means of a piece of spiral spring. This universal joint allows for slight misalignments of the mechanism.

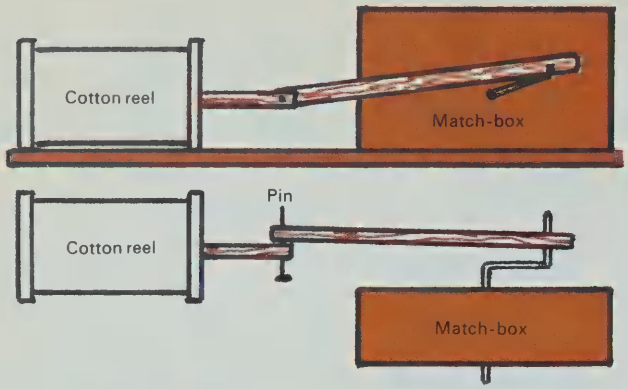
Look at a bicycle: your legs go up and down when you pedal. This motion is converted into a rotational movement by the cranks. The chain carries the motion to the back wheel. If the pedals and large cogwheel make one revolution how many times does the back wheel turn ? How does the free-wheel mechanism work ? 2.52

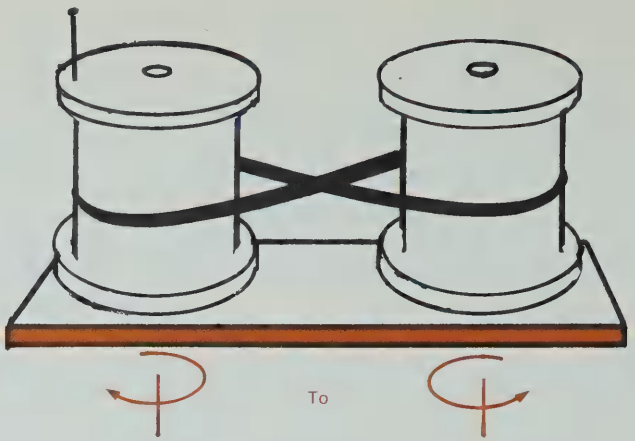
How is the force, produced by a hand, changed and transmitted to put on the brakes ?

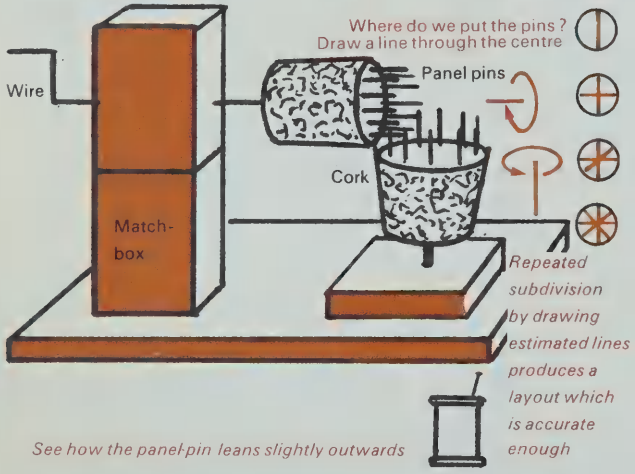
The following diagrams give some ideas on gearing mechanisms which might be useful in the building of models. In all of them something is changed, sometimes it is the *direction* of the movement, sometimes it is the *rate* of movement.





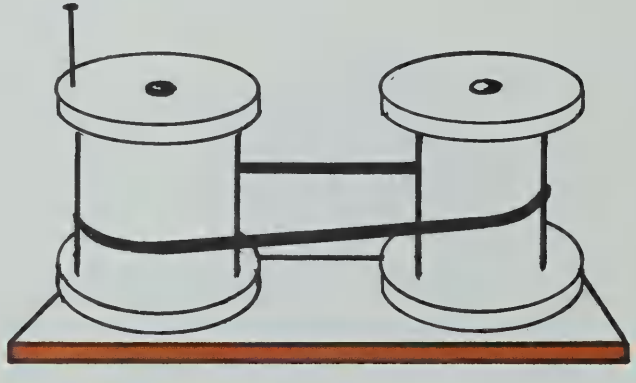


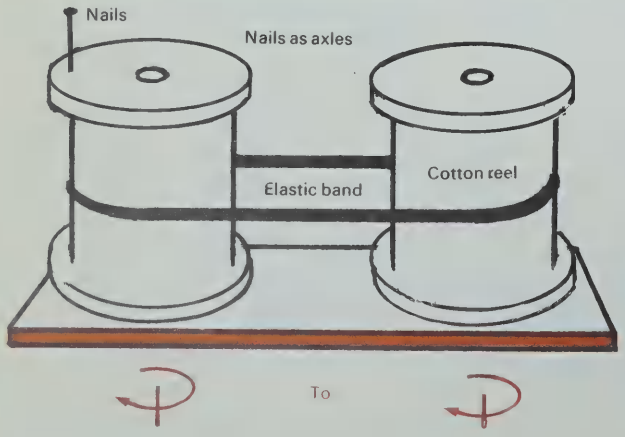


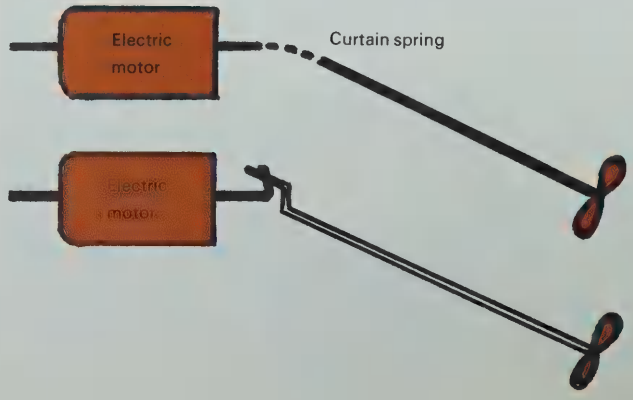


Repeated subdivision by drawing estimated lines produces a layout which is accurate enough

See how the panel-pin leans slightly outwards







3.9 Changes in position

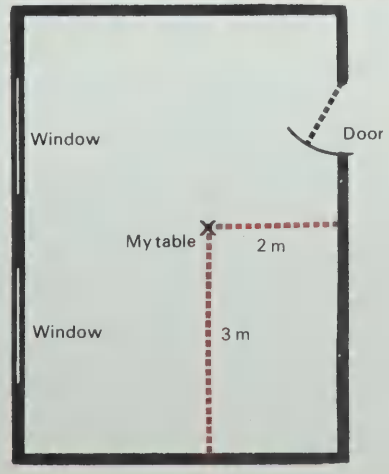
This section is about finding our way and how we can pinpoint a particular spot in space.

3.9.1 Plans and maps

Look at the classroom next door; is it the same size as yours ? Draw a plan of the two classrooms. Besides a pen or pencil, paper and a ruler what else do you require ? If a line is 10 cm long on your plan what length does it represent in the classroom ? What is the scale of the plan ? In other words, what is the ratio between 10 cm and the length it represents ? How can you find out which of the two rooms is the bigger ? What do you mean by bigger ?
1.91 2.71 1.13 1.35

If we chalk a cross on the floor of the classroom how can we describe its position so that a stranger would be able to find the spot even if the cross was rubbed out. (Hint: you are not allowed to give more than two measurements.) This would provide a good topic for discussion and maybe children will need quite a measure of skilful guidance. Work of this kind could arise during the course of a mathematics lesson and might be used to link together science and mathematics. 1.43

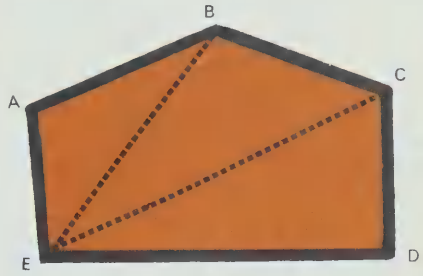
The diagram represents the plan of a classroom within a building, how can it be related to the world around ? 2.46



How can it be pin-pointed in a town and how is the town located within a country ?

If we change our position from one town to another how do we find our way ?

Can we draw a map of the school playground ? This could be much more difficult because the playground may not be a rectangle. 1.77



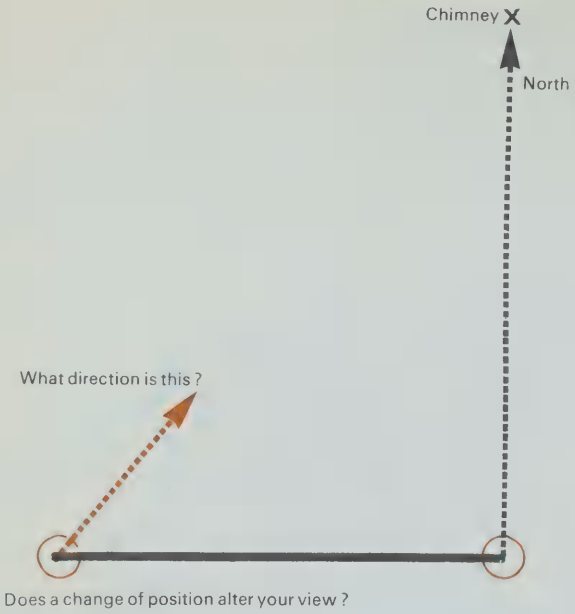
It might be pentagonal in shape and even if we were to measure all the sides we could still draw the map in many different ways. Try it. 2.86

We need some more measurements, eg BE and EC then we have split the diagram into three triangles and as we know the length of the sides of each triangle we can draw each one.

First ABE, then BCE and finally CDE.

Look at a map. What does the direction towards the top of the map represent ? This introduces North, South, East and West, and a compass. How far can children go when considering the points of a compass ? Will they get to the stage when they can divide a circle into 360°. 2.26

A simple thing to do using a compass would be to find the directions of the walls of the classroom, or paint a line showing the magnetic North to South line (remember that in 1971 the magnetic North to South line for London was about 6° West of the true North to South line) and another showing the true North to South line. (The variation of the magnetic North to South from the true North to South is called magnetic declination. The last time the two lines coincided in London was in 1660. Details of terrestrial magnetism can be found in *Whitaker's Almanack,* which gives information for working out magnetic declination for your locality.)



If a chimney is due North of you at one end of the playground will it still be due North of you at the other end of the playground ? 1.91

Make a simple map showing your route to school and put on it symbols showing some of the places and things you pass on the way; for example:

is a symbol used on maps for representing a church with a tower.

represents a church with a spire. 2.86 1.74 2.71

Devise other symbols you could use and find out about those usually used on maps. What about *Treasure Island ?*

Look for changes which have taken place in your town during the last 5, 50, 500 years. The Town Planning Department may be able to help, so might the local library or museum. See if it is possible to borrow or look at old maps or their copies and modern aerial photographs. Compare them. Ask children to look for and bring in old photographs.

If there is a local paper see if they can help. Churches and county records are useful sources. Search out the oldest inhabitants, make records in every possible way. Our towns are changing so quickly that this could well be a valuable piece of research.

3.9.2 Three dimensions

So far we have dealt only with things which are in two dimensions, ie we haven't worried much about height, but what happens if we want to pin-point a position in three dimensions, say for example a room in a particluar block of flats?

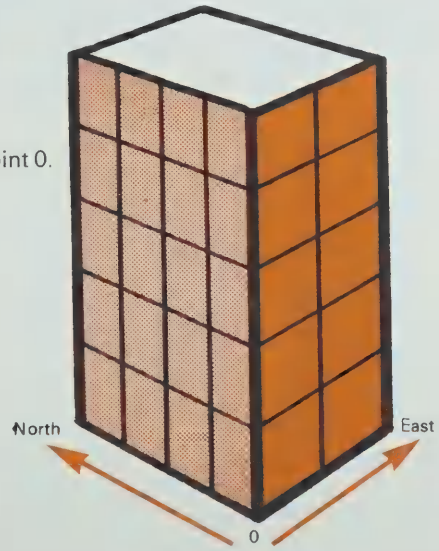
Devise several ways of telling another person how to find a particular room in a building—if your school has more than two floors use it, if not then make a 'block of flats' out of cardboard and a shoebox and use that. Now without using words but using only numbers and 'units' pin-point your room.

This is much more difficult but the 'upwards' unit could be 'floors', the two 'flat' units might be 'steps'. When you give your instructions you will have to be careful that the person to whom you are talking knows exactly what you mean when you give him the numbers. 2.74

Room X is:

4 storeys up
50 steps East
30 steps North

from reference point 0.



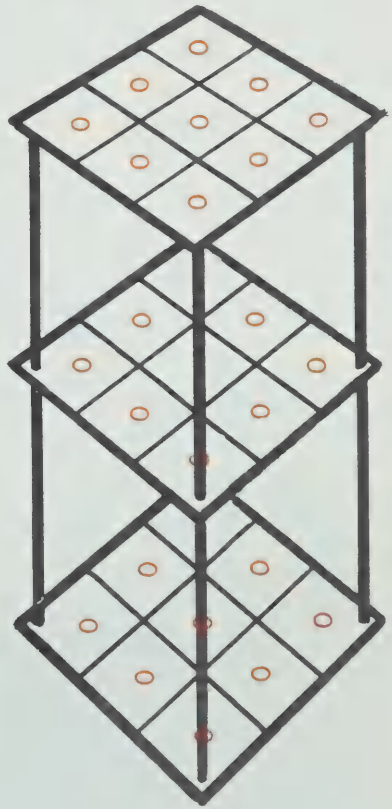
If we always use that order then the position would be:

4 storeys
50 steps
30 steps

and we wouldn't need to put in 'Up', 'East' or 'North'. 2.46

3.9.3 Helping children develop a sense of three dimensions

The following diagram shows a game of three-dimensional noughts and crosses. You play with coloured pegs or counters and like noughts and crosses try to get three of yours in a straight line. However, unlike noughts and crosses, you do not have to keep to one level but can put your peg in any of the vacant holes and the three pegs in a line do not have to be on the same level but can be straight down or even going down and across in a straight line.



Devise ways of recording the moves in a game—put up on the notice-board records of 'Championship' games. 1.72

Run a class contest: on a 'knock-out' basis and a 'league' basis.

Try playing the game with and without using the centre hole in the middle of the board. 1.14

To summarise: when dealing with two dimensions (or something which can be approximated to two dimensions) we can use two directions at right angles as our 'Frame of Reference'. If we deal with three dimensions then we need three directions all at right angles to each other.

When we wish to travel across country from one place to another we use a map. We do not know how birds navigate when they migrate.

What birds come to this country: in the spring, in the summer, in the autumn ? 1.52

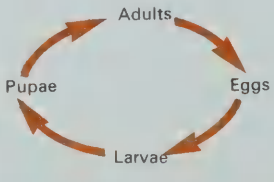
What birds leave this country at various times of the year ?

Fish sometimes breed in one place, swim away when they are full grown and return to lay eggs. Find out about the life histories of the salmon and the eel. Both of these animals travel thousands of miles from their breeding grounds to the place where they spend most of their adult life. 1.84 1.85

3.10 Changes—Butterflies and moths

Butterflies and moths provide a familiar example of metamorphosis—a change of form when the insect moults or when it changes from a chrysalis (pupa) to the adult form. First eggs hatch into larvae (caterpillars) which grow and then form pupae (chrysalises). During the summer the pupa stage of the cabbage white butterfly may last only a couple of weeks but autumn pupae last until the spring. After a suitable length of time during which at certain amount of reorganisation takes place inside the pupa, the adult insect finally emerges.

Flies, gnats and mosquitoes also have the same type of life history.



A number of colourful and interesting butterflies can be bred in the classroom. Details can be obtained from; World Wide Butterflies Ltd, Overcompton, Sherborne, Dorset, or The Butterfly Farm Ltd, Bilsington, Ashford, Kent.

4 Changes in the kitchen

At first children may only connect kitchens with cooking and food, and indeed this an ideal way to start work, but there is a lot more science going on than just cookery. *Early experiences* contains a number of simple recipes for shortbread, bread, ginger beer, butter, cheese and meringues, and if children can carry out these simple recipes then they will gain a number of valuable experiences.

This chapter contains accounts of investigations children have carried out. These are their investigations, their work, their apparatus but adult explanations have been added to show the science that lies hidden.

4.1 Washing

4.1.1 Washing ourselves

When we wash we like to use warm water and soap: this is normal behaviour, but it has not always been so. Until the nineteenth century soap was either rare or unknown and baths rarer still. Queen Elizabeth I was reputed to have bathed once a month whether she wanted it or not!

What can be found out about washing ?

In one infant school, three boys with dirty hands washed them: 1.11

a. In cold water, no soap;
b. In cold water, with soap;
c. In warm water, with soap;

and then compared their hands. As it stands the investigation could provide scope for discussion: 1.13

Is the experiment 'fair' ? 1.44

Shouldn't we make sure everybody took the same time and rubbed their hands equally vigorously ?

Shouldn't someone try washing in warm water, without soap ?

How can we record and display the results ?

Do all soaps wash equally as well ?

There are at least three sets of variables involved in washing:

i. The temperature of the water.
ii. Whether soap is used: if it is, the type and amount used.
iii. Time taken and vigorousness of the rubbing.

All this could link with TV advertisements and looking at things critically. The investigation helps to further the objectives:

Ability to find answers to simple problems by investigation and 1.41
Ability to make comparisons in terms of one property or variable. 1.42

Can you tell whether a soap is 'kinder to hands', or whether a lather is 'smoother and creamier' ? Perhaps children could question 'Why do we wash ?'

Maybe some of the older children may like to find out more about soap and how it is made—see *Soap* by O. B. Gregory.

For teachers, *Soap Bubbles* by C. V. Boys, published by Heinemann in their paperback Science Study Series, is a classic of science literature and is full of ideas and hints.

4.1.2 Washing dishes

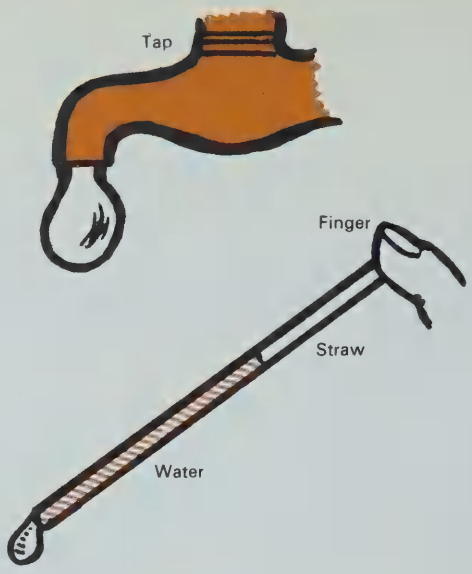
TV advertisements make much of 'mildness' and 'it really is cheaper' but what is the effect of a detergent ? 1.53

What is the effect of adding a detergent to water ?

For a start children may look at drops of water, a slowly dripping tap, milk or water dripping from the end of a drinking straw.

What are the shapes of a drop of water as it forms and then as it drops ?

Make a series of drawings showing how the drop forms and falls away. 1.77



Drops of water

Add some detergent to water in a cup, try making drops with a straw. Is it easier ? Are the drops as big as they were ? What is the shape of a drop of water on: 1.57

A clean dry plate ? 2.51

A piece of cloth from a tailor's pattern book (try different materials) ?

A piece of greaseproof paper ?

A waxed surface ?

Now dip a needle or a match into a liquid detergent and touch each of the drops in turn. The detergent has caused the water to become more able to wet things (it has reduced its surface tension, in other words the drop spreads more easily). 1.57 2.51

In particular look at the drop on the wax surface. Does this provide a clue to the use of detergents when washing greasy plates ?

Some people think if one dose of medicine does you good, two doses will do you twice as much good.

What about washing-up, does twice as much detergent wash plates twice as clean? 1.41 1.43

Can children devise a 'standard dirty plate'? After all we must be fair. But if we can use a 'standard dirty plate' then we could investigate which washing-up liquid is the 'best buy'. This would provide much in the way of measurement, discussion and recording. 2.11 2.43 2.72

Some children (of about seven years old) went on to find out that drops of water and detergent could be changed into bubbles. Their teacher commented, 'Children got great satisfaction out of this . . . They did not want to finish!' Soap bubbles can be made by gently blowing through a wire loop that has been dipped in a washing-up liquid and they can be used to show convection currents over radiators, draughts from windows and along corridors, wind turbulence over buildings.

Besides carrying out practical investigations a survey could be made of the popularity of various soaps, powders and detergents. Empty cartons could be collected and used for size and volume measurements in mathematics.

4.1.3 Washing clothes

Besides washing clothes we could also look at removing the water, but first let us start with washing.

a. Washing

As with washing hands there are a number of variables: 1.44

Temperature of the washing water.

Detergent/soap used.

Length of wash.

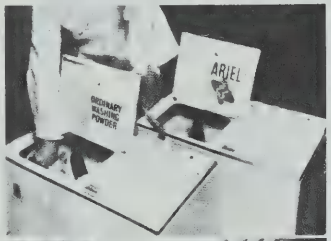
Vigour of the agitation.

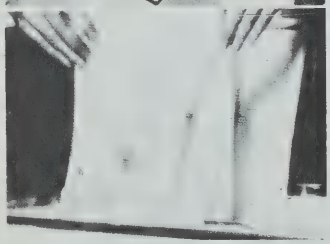
All these variables are important; no one is so important as to exclude the others as some adverts seem to suggest.

One teacher suggested that children in her class of seven-year-olds, 'only became properly aware of variables when it mattered towards the success of their project'.

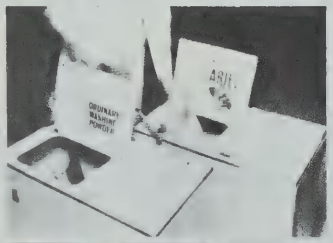
Children may like to find out if Brand 'X' is better than 'Brand Y' at washing clothes. They may like to prepare some 'standard dirty squares of material' on which they could carry out tests. 2.08 2.43

Washing in ordinary powder





Soaking in Ariel



This article is reprinted from the February 1970 issue of *Which ?* by permission of the publisher, Consumers' Association Buckingham Street London WC2

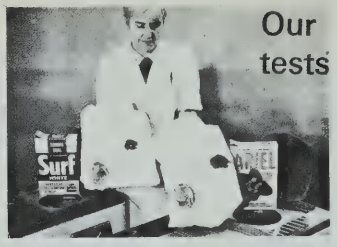
The mystery of the disappearing blood

SCENE 1 THE TV SET
AN ADVERTISEMENT
Puzzled housewife faces 'impossible' stains – blood, sweat and (no, not tears) chocolate pudding.
Washes in ordinary washing powder. They don't come out.
Soaks in Ariel, an enzyme detergent. They do.

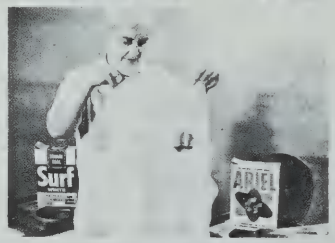
SCENE 2 CA
Puzzled *Which ?* – after all we did say last September that ordinary washing powders were just as good as enzyme detergents for nearly all washday problems.

SCENE 3 THE LABORATORY
Testers try to reproduce advertisement. Clothes with blood, sweat and chocolate pudding stains *do* come out clean when **soaked** in Ariel, *don't* when **washed** in ordinary powder.
Pause for thought.
Testers try it the other way round. Stains *don't* come out when **washed** in Ariel, *do* come out when **soaked** in ordinary powder.

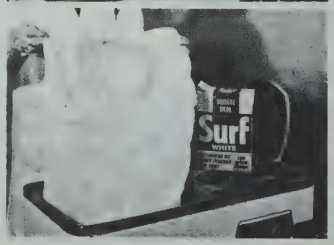
MORAL
Don't be convinced by everything you see on the telly. If you put blood stains into hot water with detergent to wash, they won't come out. If you put them into cold water with detergent to soak, they will. Cheap detergents like Tide and Surf can save you over a shilling on a Giant size packet.



Washing in Ariel



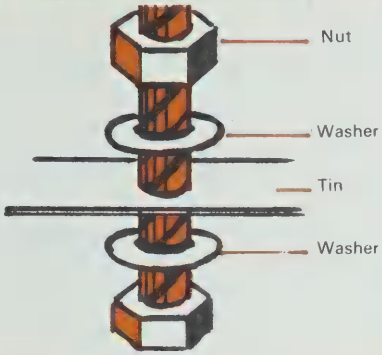
Soaking in ordinary powder



b. Spin-drying

After washing and rinsing, the next step is to get rid of the water. A 'spin-drier' can be made in several ways:

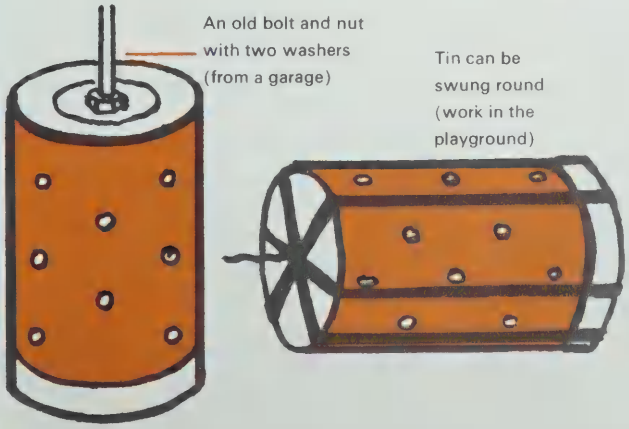
1. An old bolt and nut with two washers (from a garage).



Make sure that the bolt will fit into a chuck of a hand-drill.

The nut and bolt must be very firmly tightened before the 'spin-drier' is used; finger tightness is not enough, spanners must be used.

2. Tin can be swung around (work in the playground).



In order to prevent the tin from coming adrift from the string, tie a small nail to the end of the string then push the nail through the hole in the bottom of the can

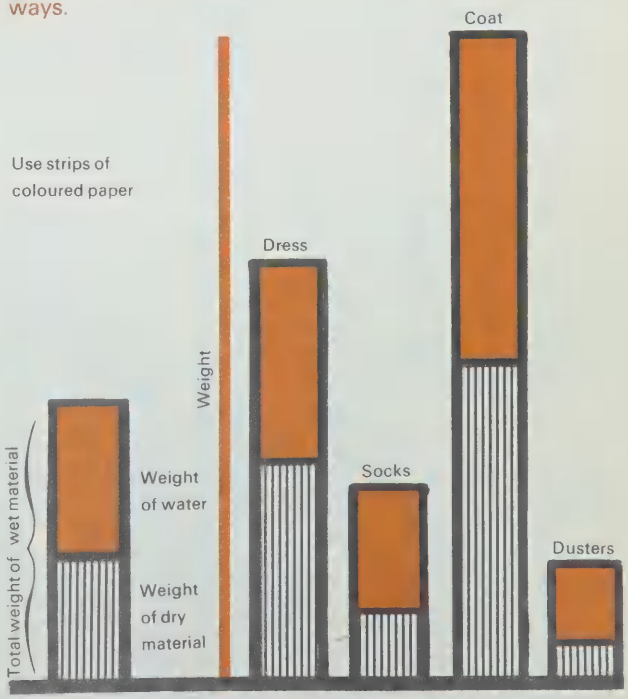
Making holes in the side of a tin can is not as easy as it sounds. If a nail is hammered into the unsupported side the can will collapse A large block of wood needs to be held in the can and the nail hammered on the side which is against the wood.

Even with a full-size spin-drier, the clothes after being spun still contain a lot of water. Children may be quite surprised if they: 1.42

Weighed some clothes after spin-drying. 1.53

Reweighed after drying them completely.

They might like to borrow a spring balance and carry out the work at home. Results that they obtain can be attractively and clearly displayed in a number of different ways.



Graph showing the weight of dry and wet materials

c. Drying in the air

How, when and where do clothes dry best? The variables which children may discover are: 1.44 2.42

How wet the clothes are.

The amount of wind.

Sun/temperature.

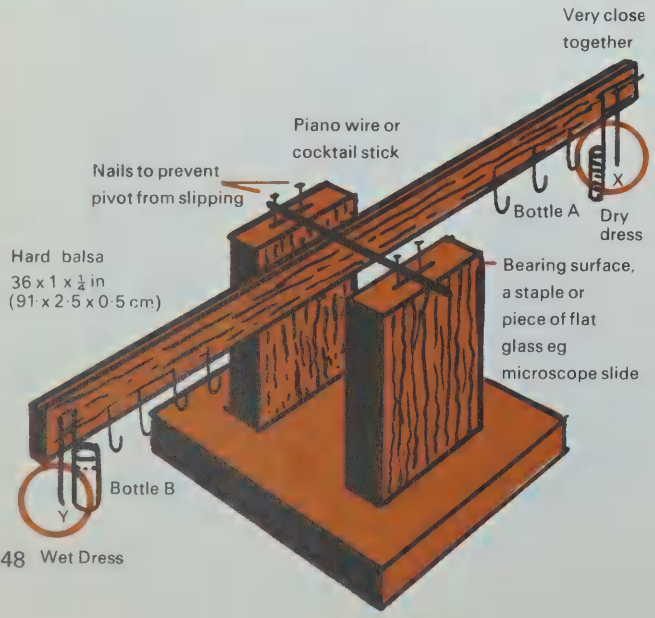
The humidity of the air (how damp it is).

The material of which the clothes are made.

One infant school reported, 'The last week of term—apron washing—we have several different kinds of aprons and the children were surprised at how quickly/slowly the different ones dried. We discussed the different materials, and re-wet some to see how the water behaved on them . . .'

Another teacher remarked, 'There is considerable confusion between damp and dry, and it seems that we need some method of recording the wetness of the material we are testing.'

The difference in the water content of a garment as it dries can be observed using the following piece of apparatus.


Very close together
Piano wire or cocktail stick
Nails to prevent pivot from slipping
Bottle A
X
Dry dress
Hard balsa
36 x 1 x ¼ in
(91 x 2·5 x 0·5 cm)
Bearing surface, a staple or piece of flat glass eg microscope slide
Bottle B
Y

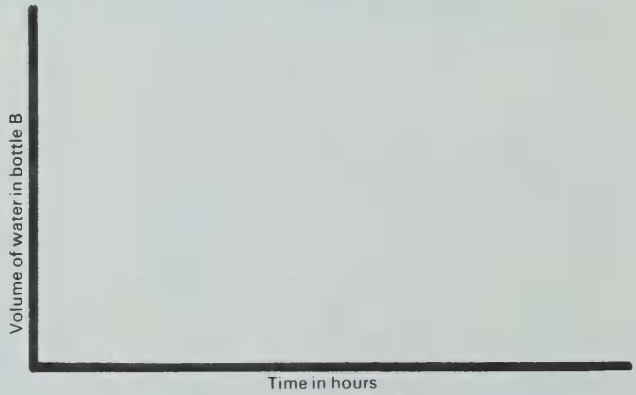
Garments X and Y are identical, except Y is wet.

Bottles A and B are identical.

Water is added to bottle A so that the balsa beam balances. 2.58

As garment Y dries it becomes lighter, therefore the other end of the beam goes down. 2.56

Water should be added to bottle B to maintain the balance. This amount of water is almost the same as that which evaporates from Y. In one school, the children said that the water which they put into bottle B was not equal to the water which evaporates from the wet dress. They were quite right. Children who appreciate this are beginning to build up an understanding of moments.



Graph showing the drying of a wet handkerchief in air

There is one interesting point to note—the rate of drying is almost constant until the fabric is nearly dry. This is likely to be due to the fact that evaporation is a surface phenomenon and while there is an unbroken surface the rate of evaporation will be constant (all other variables being constant). 2.72

4.2 Cooling things

We can start with hot things and allow them to cool or we could start with things at room temperature and cool them in some way.

4.2.1 Cooling hot things (see 'Clothes and climate', 3.7.3)

Hot things cool down and cold things warm up until they reach the temperature of their surroundings. If we want to cool a cup of hot liquid, we could pour it into a saucer and blow on it, or we could just leave it in a china cup, or pour it in a metal jug: there seem to be a large number of ways whereby we can cool a cupful of hot liquid. The variables governing the cooling of a liquid need setting out. They are:

Initial temperature.

Room temperature.

Weight of hot liquid.

Total area of liquid exposed.

Amount of cooling air, wind.

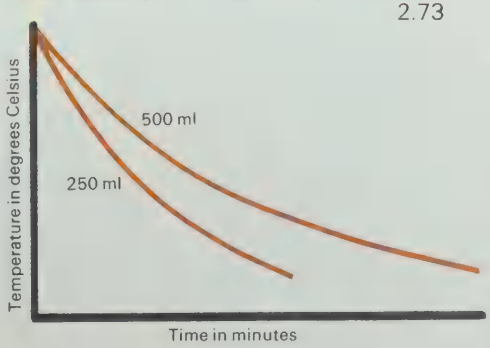
The thickness, conductivity and radiating power of the container.

The composition of the hot substance (not all substances of equal weight have equal capacities for heat; metals for example, have only about a tenth of the heat capacity of water).

Although this appears to be a formidable list, children can easily investigate one variable provided they keep all the others constant. (We can conveniently ignore at this stage the last of the variables.) 2.43

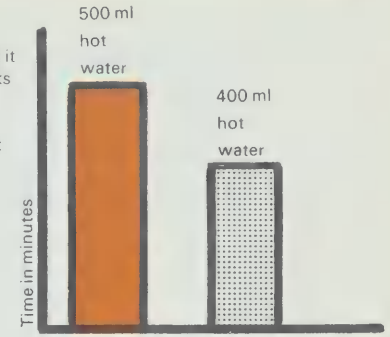
For example: they could pour different amounts of boiling water into china cups and record the temperature using a −10/+110 °C thermometer every minute. They could plot their results. 2.73

Graph showing the cooling of different amounts of hot water



If a thermometer is not available a piece of candle wax could be dropped into each cup and the time for it to set measured.

Graph showing how long it takes for different amounts of hot water to cool sufficiently to allow a piece of candle wax to set



Or if they kept the volume constant they could try the affect of insulating the vessel with cotton wool, fur, woollen material, etc (see section 3.7.3). Once again the temperature might be taken every minute and the results plotted on a graph. 2.56

The same amount of hot water could be poured into various vessels of differing shapes such as a cup and a soup plate, and the rates of cooling compared.

A team race could be set up to see how quickly a cupful of hot water could be cooled using any or all of the methods they have discussed. To make the 'competition' fair a team should discuss what they are going to do, collect what they need and then all teams should start together. This would encourage the children to plan ahead and to make use of what they have discovered previously. As well as considering cooling things, children might investigate how to keep things hot, in which case the same variables as for cooling, are involved. 2.11 2.45

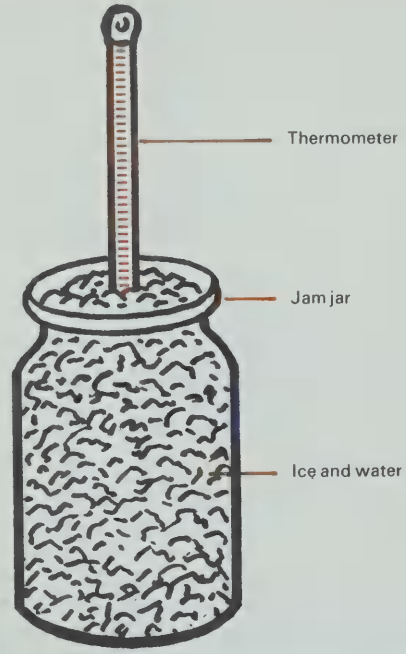
4.2.2 Cooling cold things

This is what happens in a refrigerator, things are cooled below room temperature. In the freezing compartment water can be frozen into ice. Ice provides the raw material for a number of investigations, for example at what temperature does ice melt ?

Sources of ice: school canteen, fishmongers, home refrigerators, winter weather: use a Thermos flask to carry and keep small quantities of ice. How long will a given amount of ice keep frozen in a Thermos flask ?

a. Take a jam jar and fill it with crushed ice cubes—made by wrapping the ice cubes in a duster and hammering with a mallet or hammer.

Then add some water and stand a thermometer in the mixture.



There must be an excess of ice over water otherwise the ice will not cool the water sufficiently.

Leave the thermometer in the mixture for a few minutes then read it.

It should be 0 °C but if it isn't, it is likely to be either that the thermometer is wrong or there isn't enough ice in the mixture.

b. Take an ice cube, dry it in a duster and then stand it on a saucer and put on it a pinch of salt. *Listen* and watch.

What happens? 1.53

The results of this investigation could be linked with the melting of ice and snow on roads. 1.81

c. Crush some ice then put layers of ice and salt into a jam jar.

Add a small quantity of water and then put a thermometer into the mixture.

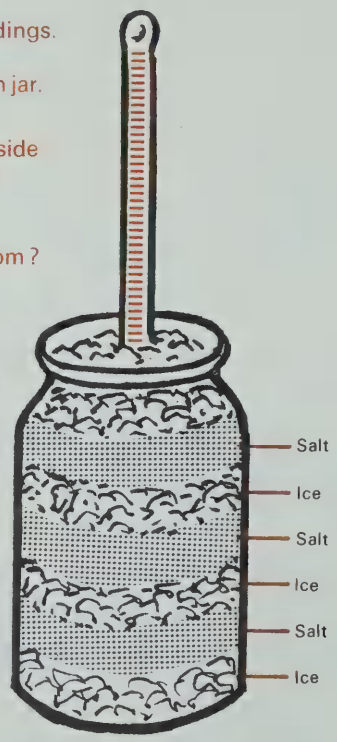
Observe:

The thermometer readings.

The outside of the jam jar.

Is the frost on the outside of the jam jar coming through the glass?

Where is it coming from?



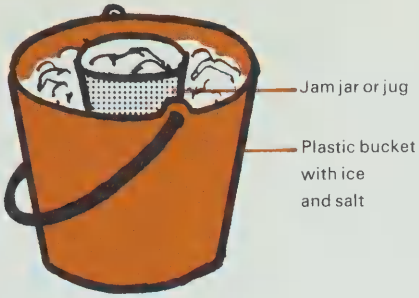
A freezing mixture

Using their observations children could devise means of freezing a small quantity of water. They could also find out if they can freeze common liquids such as paraffin, methylated spirits, milk, tea, fruit juice, etc.

The making of ice-cream is not beyond them provided that there is sufficient ice available.

Using a packet of ice-cream mixture obtainable from a grocer, carry out the instructions regarding the mixing of the powder with milk.

Pour the cream mixture into a jam jar or jug and stand the container in the freezing mixture.



Making ice-cream

Leave until the cream has begun to freeze then stir it vigorously for about a minute.

Once again leave until the cream mixture has completely frozen.

It is then ready for sharing out!

4.3 Changes when things are heated

Many foods require cooking. What effect does heating have on them? Is there a change in properties? If so, what properties have changed? Do we always like the change? Or make use of the change? Is the change reversible? A very important point is that heat is a form of energy and it is energy which causes the changes?

1.81 1.57 2.51

a. Water

What is the effect of boiling water? What does cold freshly boiled water taste like? If a glass of really cold water freshly drawn from the tap is allowed to warm up in a classroom or over the radiators, what do you notice on the inside of the glass? What do you think these bubbles are? If cold boiled water is put into a clean squash bottle, so the bottle is half full, the stopper replaced, the bottle shaken vigorously for five minutes and then the water tasted, has it lost its 'flat' taste? Is the effect of heating water a permanent change? 1.57 1.04

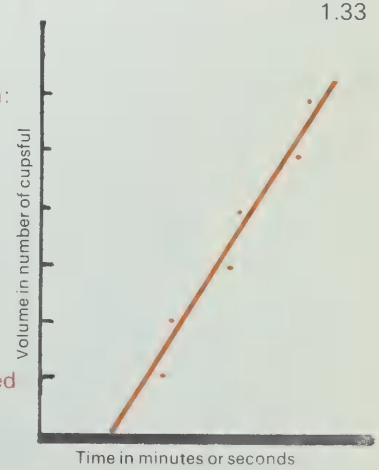
How long does it take for a kettle to boil? How do we know when the water begins to boil? If a thermometer is not available use a whistling kettle. Does it take twice as long to boil two cupsful of water as it does to boil one cupful? 1.33

A graph could be drawn:

If through the points a straight line is drawn it does not go through the 0·0 mark. Why?

Apparently it takes some time to boil no cupsful of water! Is this reasonable?

What else is being heated besides the water?



Graph showing the length of time it takes to boil varied amounts of water

b. Milk

What is the effect of boiling milk ? Does it look the same after it has been boiled and then cooled ? Does it taste the same ? Does the boiling milk cause a permanent change ? 1.57

c. Eggs

What happens to an egg when it is cooked ? In what ways are a boiled egg different from an uncooked egg ? 1.57 2.51

d. Fats and waxes

Into a cold cup put a piece of candle; add some boiling water. What happens ? What happens as the water and wax cool down ? Does cooking fat behave in the same way ?

e. Bread and toast

In what ways does toast differ from bread ? Investigate the colour, stiffness and water content.

f. Metals

Metals are often used for cooking utensils. Are they affected by heat? It would be best to have two pieces of copper (clean 'copper' coins), aluminium (cleaned milk bottle tops or foil) and steel (cleaned, deliberately blunted razor blades). One piece of each metal could be boiled in water for some time and then compared with the other specimen (this is called a control). If there has been a change the specimen must be cleaned to match the control before starting the next test. 2.43

In an oven the temperature often is higher than the boiling point of water (100 °C), how do metals stand up to this ? Does change take place ? Put the pieces of metal on an electric hot plate or the heating rings on top of a cooker (gas cookers can be used but the specimens have to be held in a pair of tongs, and often the heating is too quick so that the effects are over too quickly). Raise the heat slowly and see what happens—don't let the metals become red hot, ovens never reach this temperature when cooking. 2.56

Some of the colour changes in this investigation are very attractive and are of practical use in the tempering of steel (see the Project's book on *Metals*). 1.17 2.12

g. Other possible lines for investigation

There are many other questions which can be asked and investigated:

Why does milk boil over but not water ?

Why is the top of the oven the hottest ? Is it ?

How does a coffee percolator work ?

How is the temperature of an oven measured ?

At what temperature does water boil ?

Does a strong solution of salt water boil at the same temperature ? 1.41 2.41

How hot does the inside of a roast potato get ? Get a potato, wash it but do not peel it. Put the potato in a baking tin and roast it in an oven at Regulo setting of 4 or 350 °F for about an hour. Remove the tin and contents from the oven. Hold the potato in a cloth and with a pencil bore a hole in it. Push into the hole a 360 °C thermometer (a 210 °C thermometer will do just as well) and read the temperature of the inside of the potato. 2.56

Considering the temperature of the oven (nearly 180 °C) do you find the temperature of the inside of the potato surprising ?

4.4 Differences in powders

4.4.1 Powders in the kitchen

How many powders can you find in a kitchen ? Mount a display showing what powders are available, how they are sold, the cost, what they are used for, the weight of a tablespoonful of powder and so on. 1.05

How can a powder be made ?

Suppose you require icing sugar but only have granulated sugar, how could you make some ? 1.33

What changes must take place ? 2.51

How is energy involved in these changes ?

How could you make sure the icing sugar doesn't contain lumps ?

Make a sieve from a piece of nylon stocking and cardboard box and use it to sieve powders. Why won't some material go through the mesh ?

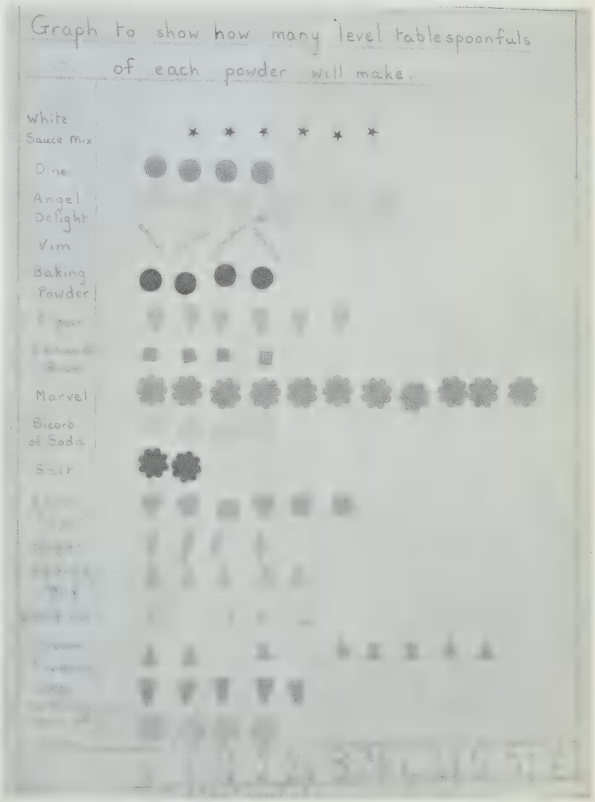
Making use of your work: Peppermint creams

Ingredients:

1 white of egg
1 teaspoonful water
Icing sugar
Oil of peppermint essence

The sugar, after grinding, needs sieving. Then beat the egg white with a fork and add the sugar until the mixture is stiff. Add the water and a few drops of essence and beat again. Then add more sugar until the mixture will knead. Turn out on to a piece of greaseproof paper. Roll out and cut into shapes. Allow to set in a warm place. 1.57

List the changes which you have caused since starting with an egg, sugar and water. 2.51

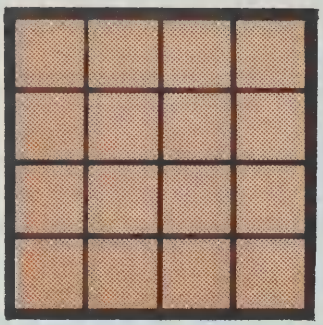


Powders in the kitchen

4.4.2 Looking at sieves and holes

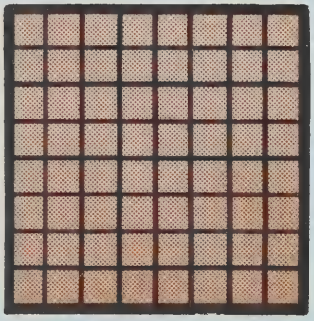
Sixteen holes in one square.

A



Sixty-four holes in one square.

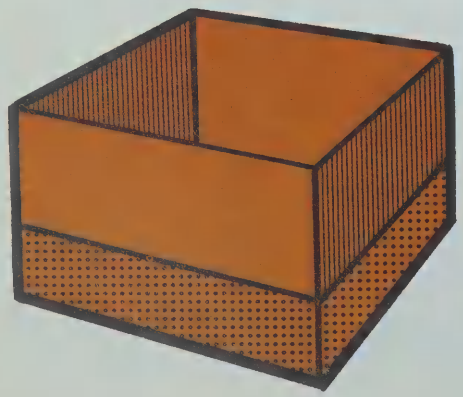
B



Making a sieve:

Bottom cut out of a cardboard box and a nylon stocking stuck with balsa cement, latex or rubber cement.

Is there anything else which could be used as a sieve ?



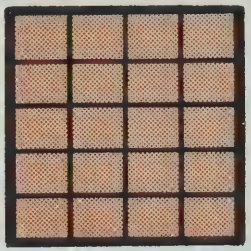
Sieves

Sieves are useful things: they can be used for sorting things, they can also be used to help children to develop ideas of their own of area. Using squares of paper they could draw sieves containing different numbers of holes and discover a connection between the total number of holes and the number of holes on adjacent sides.

Twenty holes in one square.

What is the shape of one hole ?

C



First they could use squares containing the same number of holes on adjacent sides (figs. A and B). Then they could construct a square with a different number of holes on adjacent sides (fig. C). This might well fit in with mathematics.

4.4.3 Let us make some sweets

Let us make some sweets. It will be surely something which will interest all children, boys as well as girls. (Boys are interested in cooking just as girls are interested in mechanical toys. In one secondary school a newly appointed HE mistress decided to run an after-school cooking class for boys. Seventy boys turned up !) There are plenty or reasons for sweet-making: Christmas, birthdays, Easter, fetes and holidays, open days and Parent-Teacher Association evenings all provide reasons.

If no form of heating is available then the range is restricted but the following are still possible:

Peppermint creams	Coconut ice
Marzipan	Fondants
Instant Whip	Sugar icing and cake fillings

With heating facilities all sorts of things are possible particularly if one of your pupils is used to doing some cooking at home.

Certainly there is here an activity which is highly motivated, what can be got out of it ? We need to look for the changes which take place, some of which may be:

Powders	How are they made: what are the shapes of the grains; sieving and sieves.
Colour changes	Use *edible* colours.

Changes in consistency

Do any of the sweets dry out ?

How could this be investigated ? Do peppermints develop a 'crust' ? Does a crunchy peppermint contain less water than a soft one ?

Coconut ice

3 tablespoons condensed milk
8 oz [225 g] icing sugar
6 oz [170 g] desiccated coconut
Red colouring

Mix together the condensed milk and sifted icing sugar.

Stir in the coconut to make a thick mixture.

Divide into two portions: leave one half white; colour the other portion pink.

Grease a small tin (use a loaf tin 4 in × 6 in [10 cm × 15 cm]) and place white mixture in the bottom of the tin: red mixture is put on top and smoothed out.

Divide into 1 in [25 mm] squares: allow to dry for one day.

Coffee creams

1 egg white
12 oz [340 g] icing sugar (sifted)
$\frac{1}{2}$-tablespoon coffee essence

Mix all the ingredients together.

Roll out mixture on a surface covered lightly with icing sugar to $\frac{1}{4}$ in [6 mm] thick.

Cut into 1 in [25 mm] rounds. Leave to dry.

Stuffed dates

1 pack of dates (whole and separate)
4 oz [112 g] almond paste—marzipan
Green colouring

Stone the dates.

Halve marzipan and work green colouring into one half.

Roll each lot of marzipan into sausage shapes and stuff the dates.

Marzipan cherries

4 oz [112 g] marzipan
4 oz [112 g] glace cherries

Shape the marzipan into balls about $\frac{3}{4}$ in [18 mm] in diameter.

Cut glace cherries in half and press a cherry half into each end of the marzipan ball.

4.5 Dissolving things in water

We often dissolve things in water: we add boiling water to tea leaves, something dissolves, there has been a change. Sugar and milk are added, they dissolve: another change takes place. Make a list of things which are dissolved in water at home. 1.53 1.29

4.5.1 Do all things dissolve in water?

How can we find out whether something is soluble in a liquid? The easiest way is to take a glass of cold water and stir it with a spoon and add some of the solid. If it disappears then the substance is soluble in water.

2.56 2.02

Soluble, dissolves quickly	Not very soluble, dissolves slowly	Insoluble, does not dissolve
Sugar	Bicarbonate of soda	Scouring powder
Salt		Pepper
Epsom salts		Metals
Health salts		Flour
Soda		Candle wax
		Moth balls

Does heating the water help things to dissolve? This is an example of supplying energy to encourage change. 2.51

Does the fineness of the powder have any effect on the *rate* of dissolving? Try dissolving one spoonful of icing sugar and a spoonful of granulated sugar in cups of water —stir both at the same rate. Which dissolves the fastest? Why do you think that this is so?

By the way, does your tap water contain anything dissolved in it? Put a clean saucer filled with tap water on top of the radiators. Examine the saucer when all the water has evaporated. Is anything left behind? 2.56

4.5.2 Getting back what you started with

If we stir a spoonful of salt into a cup of water the salt *apparently disappears.* It must still be there because the water becomes salty, but how can we get it back in its original form? The problem is similar to the drying of clothes. In both cases water has to be got rid of and the solid left behind.

Put some salt solution in a saucer and leave it until the liquid has evaporated. What is left behind? Can the process of evaporation be speeded up or slowed down? If saucers containing the same volume of solution (in order to be 'fair') are put in different parts of the classroom which solution evaporates the quickest? Why? 2.51 2.42 2.43

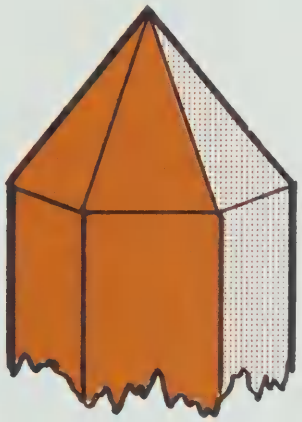
(Look for wind and temperature.) This could be compared with the drying of clothes—when do clothes dry quickest? Use a plan of the classroom (made by the children) to show the position and order of drying up of the liquid. Sea water might be used: it tastes salty, can you get the salt from it? 1.53

If children try various solutions such as those of epsom salts, sugar and soda in different saucers and allow them to evaporate they may be able to see the formation of crystals. This is always a most intriguing process and is sure to arouse interest.

The slower the rate of evaporation the larger the crystals will be; leave the solution to evaporate over night. 2.42

Crystals can be made by allowing a few drops of solution on a piece of glass to evaporate and then examining the crystals with a magnifying glass, or under a microscope if one is available. 1.57

This work could be linked with natural crystals found in minerals and rocks and pebbles found on the beach (see page 20).



Crystal of quartz

4.6 Other changes in food—Decay

What about food which goes 'bad' What happens to milk if it is left ? What differences are there between fresh milk and milk which has 'gone off' ? How long does it take for milk to go bad ? Does the temperature have any effect on the time ? Will boiled milk go bad ? Does it go bad as quickly as unboiled milk ? Will milk which is kept in the refrigerator go bad ? 1.27

Sometimes work on these lines is initiated as the result of a fortuitous accident '. . . two girls who had made the custard wanted to use the remaining powder and so experimented using cold milk This mixture, which they did not eat after tasting, was left and overlooked over the half-term holiday with the result the milk became sour Left a further week a mould started to grow on the surface.'

The souring of milk has started some children looking at cheese-making, and the wide variety of available cheeses; at junkets and rennet and at yogurt. In every case the milk is changed from a liquid to a solid or semi-solid. 2.11

What happens to a piece of bread if it is kept dry over the radiators or if it is kept damp on top of a cupboard ?

What changes take place when an orange goes bad ? Does it change in weight ? What is that green stuff on a rotten orange ? Look at it under a magnifying glass—what does it look like ? Will it grow on other things ? What happens if a piece of orange skin with some green mould on it is dropped into boiling water, left for a few minutes, and then taken out and left ? Does the green mould go on growing ? (What about the story of penicillin ?) 2.51 1.81

Let the children look around and find out where decay is going on—what happens to dead leaves ? They may come across rotten wood; how does man prevent this change from taking place ? There is just one warning, not all change is due to decay. One child had a very ingenious theory as to why iron rusted. He thought that it was due to a rust insect and he compared rusting with the red dust he had seen on some trees. Such a clever and well thought out theory could not be squashed, but he had to be guided until he himself had rejected his idea. 2.08 2.51

All this leads on to finding out about the disposal of kitchen and home waste It will tie up later with bacteria and hygiene. By the way, how much water does a household use every twenty-four hours ? 'Children were surprised to discover that washing their hands under running water used less water than when they used the basin stopper.'

4.7 Other ideas on change which might be investigated

4.7.1 Measurements

Quite a lot of measuring is required in cooking—weights, volumes, times While this may not be directly relevant to change it does help children with experiences which will be of general use. Sometimes the use of measurements help to pinpoint changes, as for example, if a slice of bread, or an apple or a potato is left and weighed at regular intervals it will be found that there is a *gradual* loss of weight Something is changing but what ? This can be a very complicated problem but the initial method of taking weighings is simple in its idea and has been used in some complicated research problems in fields far removed from cooking. 1.43

4.7.2 Altering shape/size

What do we use for cutting? Why aren't all knives the same shape? What shapes are used? How do we sharpen knives? What are knives made of? Do they rust? Why does iron and steel rust? (see *Metals Stages 1 & 2)* 2.56

How can you mash potatoes ? Can you tell the difference between cooked potatoes which have been mashed and packet mashed potatoes ? Try it out and see if a panel can tell the difference ? See which they like best—see which is the 'best buy'.

4.7.3 Things in the kitchen which bring about change

First of all consider what changes take place in the kitchen (or home) Then list how the change is brought about and finally think of examples.

Example:

Change	How it is brought about	Examples
Separating	Pouring off a liquid from a solid Sieving and strainers Cutting off fat, skins	Orange juice Flour, tea Apples, potatoes

4.7.4 Colours and change

a. Matching colours

If there is a colour change we must be able to compare, either visually or in our mind's eye, the original colour with the new one. How good are we at doing this ?

A collection of colours could be made from paint colour cards and a game played:

One child could show a colour for say ten seconds, and then cover it up. The others must pick out from their cards the matching colour *after* the display colour has been covered up.

There are a number of investigations which could be based on this. 1.13

Do you get better with practice ?

Do you get better with age ?

Can you fool your colour sense by enclosing the matching colour with a border of another colour ? 2.08

b. Separating colours

When making sweets some edible colours might have been used. Sometimes these are a mixture, for example green is usually a mixture of blue and yellow. These can be separated by a simple technique called chromatography, (meaning writing with colour). Sometimes when a blot of ink spreads on a piece of blotting paper rings of different colour are formed because the ink colours have been separated from each other. An ink of a single colour will not separate; Quink Permanent Black Ink is a mixture which can be separated, so can the inks found in Pentel pens (black) and Paper Mate pens (black).

A possible flow chart might be:

Ink blots ↓ ⟷ Symmetry in mathematics 2.24

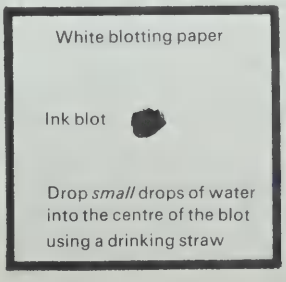
Separation of colours ↓ Is a colour a simple one or a mixture ? 1.59

Chromatography ↓ What do we mean by a simple substance or a mixture ? 2.51

Can we separate other colours ?

Techniques of simple colour separation (chromatography).

A



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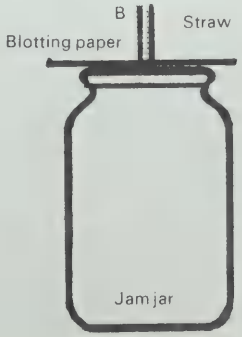
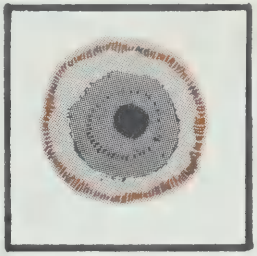
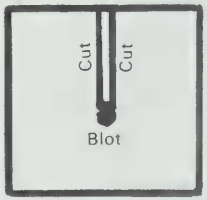


In place of water try methylated spirits. Other common household liquids, eg paraffin, milk, cleaning fluids, petrol are not much use.

C

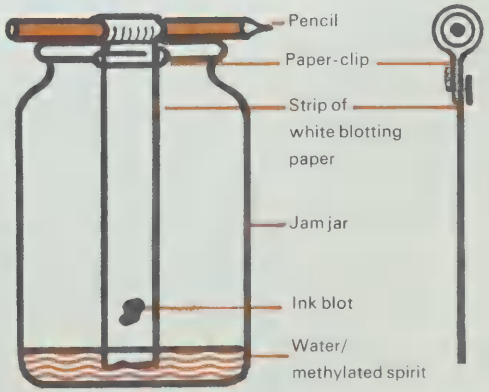




The water ascends the wick by capillary attraction

Once this has been set up it can be left to operate on its own.

A simple version of a laboratory method.



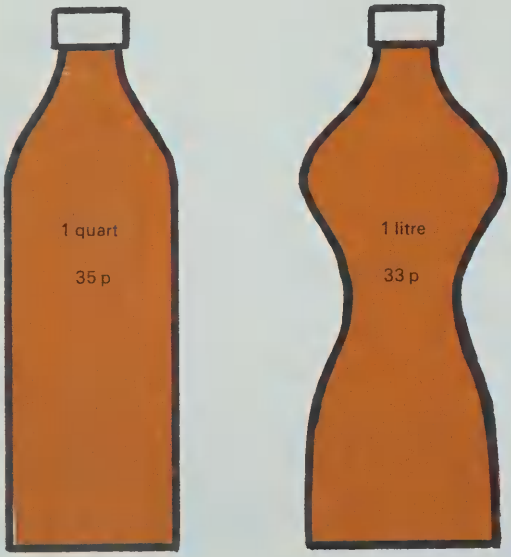
Note. Chromatography can be used to separate *soluble* dyes, or an *insoluble* dye from *soluble* dyes, but it cannot be used to separate *insoluble* dyes or pigments one from another.

4.7.5 Containers and metrication

During the next decade there will be a change from Imperial to metric units for everyday usage except in cases where the old unit is convenient, is accepted and a metric conversion would be pedantic. Should we metricate 'tablespoons' or 'teacups' when the added accuracy is unwarranted ? A conversion from quarts to litres might be a temptation to some manufacturers or retailers to hide a price rise. 2.45

Look for examples like the following:

Before metrication After metrication



1 litre = 1000 cm³ ≏ $1\frac{3}{4}$ pints (1·7598 pints).

1 quart = 1·1365 litre.

The whole business of changes in packages could be looked at, eg how was milk delivered in 1900 ? How is it delivered today ? There is a lot of mathematics and science in packaging. Consider:

Shapes do the packages fit together ? 1.23 2.23 2.24

Sizes linear, volumes, weights.

Materials { What are the containers made of ? Why ? How suitable are they ? How can the empty containers be disposed of ? Rubbish disposal. Pollution. Hygiene and prevention of contamination. 2.93

There is quite an important ratio which engineers consider when they build a structure like a rocket and that is:

$$\frac{\text{The weight of the useful contents}}{\text{The weight of the container}}$$

The bigger this ratio is, the more the engineer smiles. What is this ratio for:

A box of chocolates ?
A carton of corn flakes ?
A bottle of milk ?
A satchel ?
An egg ?
A car (what are the 'useful contents' ?)

How have we made progress in improving this ratio ?

4.7.6 Let us make butter

'One group decided to make butter from cream. Everything went satisfactorily and they challenged the class to distinguish their product from a commercial brand. To their delight about a quarter of those tested couldn't tell the difference between the two.'

How is milk changed into butter ?

Milk consists of drops of fat mixed up (dispersed) within a watery liquid When milk is allowed to stand the cream rises but it is still drops of fat dispersed in a watery liquid When the cream is shaken (churned) the drops of fat join up to form a lump of fat containing small drops of water. This is butter. 2.86

The butter fat content of milk varies between about three and five per cent of the total milk. When you buy a pound of butter how much milk has gone into its manufacture ? (Take the butter fat content as being five per cent and that 1 pint of milk weighs 1·25 [$1\frac{1}{4}$] lb.)

5 Background for teachers

5.1 Introduction

This chapter is put here so that after looking at work which is possible in the classroom, teachers might read about some of the ideas which lie behind the everyday facade. Change has been argued about ever since philosophy became a topic of academic concern. The Greeks, first recorded philosophers, were divided upon change, some contending that the universe and all in it was immutable and that change was illusory. Others, believing the evidences of their senses, perceived the changes around them and questioned the 'How', 'Why' and 'Wherefore'. In their world life seemed to go on much the same from day* to day and those changes which did take place seemed to be due to the gods.

But today he would be a brave man who dares to predict the world of tomorrow.

Events change so swiftly that often the shrewdest predictions are out of date before the print is dry. It was Rutherford, the first man to split the atom, who said that the production of atomic power was a wild dream because more energy had to be put in than could be got out. Twenty-five years later the atomic bomb was dropped on Hiroshima. Fifteen years on and eminent astronomers were ridiculing the idea of space travel, within a decade they too were eating their words.

So often the forecasts are wrong because progress does not go on at a steady rate, but at one which is accelerating all the time; we are apt to judge by existing materials, standards and the state of our theoretical knowledge. In 1939 a practical TV set the size of a packet of cigarettes could not be imagined possible because transistors and micro-circuits had not been developed, nor indeed had the scientific principles, on which they are based, been discovered.

Consider the time it has taken mankind to develop, the stone axe, the bronze axe, the iron axe and the laser beam, or think of the changes in transport in the last 150 years compared with the previous 1500 years.

Change is not confined to the material world; our ideas are undergoing constant change and revision. In the fields of education and philosophy for example, we can see the pendulum of ideas swing backwards and forwards, always on the move.

5.2 Change is all around us

'Everything changes, nothing alters', says an old saying and therein lie two very important ideas. Everything changes, yes that is so; nothing that we touch or handle remains the same for ever. In some way the passing of time allows some agency of change the opportunity to bring about a change of properties however small.

At the same time 'nothing alters'. Here we have one of the fundamental ideas of science and philosophy. Things may change but the basic material of which they are made can never be destroyed. This has not always been accepted and some philosophers do not accept the converse; they think that it *may* be possible to create something out of nothing.

All round us things change. Material things are changed; even the solid earth is being constantly changed by the forces of nature, while the immaterial ideas of man change and whirl like the patterns of a kaleidoscope. Change occurs even in the simple things of life. The making of a cake or the lighting of a match involves changes just as

does the repudiation of an ideal by a generation or the overthrow of a government by a revolution.

5.3 How do we recognise change?

To recognise change taking place in something we must be able to compare this something before and after the change has taken place. This may not be as easy as it sounds. How can we preserve the image of something? It needs describing in precise and accurate terms; in other words we must be able to describe the 'something' in terms of its properties and then to compare these properties before and after the change. So one of our big objectives is to get children spotting *differences* because you can't think of change without them.

Even when the changes which take place are not material, such as changes in ethics, emotion or behaviour, they can only be recognised when a definable property or attribute at one moment in time no longer matches the same property or attribute at another moment in time.

5.4 Change and properties

There are certain intrinsic properties of objects which are familiar to us, properties of size, shape, colour, motion, form and composition. These provide the terms by which we describe an object and are to a large extent universal, recognised by people of different races and upbringing. The idea that water is both wet and liquid is universal. The proper description of properties is as much a part of language as is the description of a 'host of golden daffodils'.

There are other properties which are not so familiar, some because they are so complicated; some because they are hidden by more prominent ones. Sometimes we lack the senses to perceive them and only become aware of their importance when we devise special sensory apparatus to do the work for us. One property of metals which profoundly influenced the aircraft industry when jet planes were first used by commercial airlines was work-hardening and fatigue. One remembers the De Havilland Comet air disasters, the price Britain had to pay for venturing into unknown fields and coming up against properties which were unexpected, hidden, overshadowed and which we could not detect at the time.

5.5 Change and energy

We hammer metal to change its shape, or chop down a tree and burn the wood; a sculptor carves a figure from a block of marble; a foundryman melts a lump of metal and casts an engine block; a cook bakes a cake; rivers silt up or rain beats down a field of corn. In all these examples energy changes are involved as well as material changes. Sometimes energy is required in order to make the change, as, for example, in chopping down a tree. Sometimes it is given out as a result of the change, as in the burning of the wood. Life itself depends upon energy changes and a study of living organisms must introduce at some stage a study of energy reactions which take place in living matter. Whenever we study a change we ought to look for the involvement of energy and this should be implicit even if it is not mentioned in the text.

5.6 Change and time

Time is another of the essential factors in change; all changes take some time however small. Sometimes change takes place very slowly indeed so that during the span of one man's life the change is undetectable, but over a long period of time the small changes add up to something which is noticeable. This is what happened when the length of the year was fixed by the Julian Calendar in 45 BC. Unfortunately, there was a slight error in the calculation of the year which could be ignored in one man's lifetime but by 1752 amounted to eleven days. (That year Great Britain and her dominions, which included her North American colonies, put the calendar right by leaving out eleven days. Mobs rioted crying: 'Give us back our eleven days.')

Many evolutionary and geological changes are slow, but today scientists are interested in changes which take place in a tiny fraction of a second. A nanosecond (10^{-9} second or $\frac{1}{1.000.000.000}$ second, or approximately the time it takes for light to travel one foot) is for some work, eg in computers and nuclear reactions, quite a long period of

time. (There are as many nanoseconds in one second as there are seconds in a lifetime.)

5.7 The effects of change

Changes of the material world, however small, affect the environment and the effects are likely to be cumulative if they are too small to have an immediate impact. For example, the Great Lakes of North America have slowly become so polluted that under present conditions they are past the point of no return.* They can never return to an acceptable condition unless North Americans were completely to stop discharging wastes into the lakes and even then it would take a lifetime to restore the balance of nature.

Pollution has become a world-wide problem largely because its effect is cumulative. Everyone thinks that their mite will not have any effect but cumulatively the result may be disaster.

It is not just in the material world that change can be seen. New ideas can have far reaching effects particularly when a definite attempt is made to influence people. The effects of advertising and propaganda carried out by press, radio, TV and education can change the behaviour patterns of a nation. We might well consider 'pollution of the mind'.

5.8 Is it worth it?

All change has to be paid for, be it in terms of energy, convenience, time, aesthetics, or money and sometimes it is profitable to stop and ask oursleves 'is it worthwhile?' 'Will the change we are striving to bring about be bought at too high a cost?'. Whatever we do will introduce a change into our environment; is it worth it? We must make an ethical judgement and consider who will benifit and who will lose. Seldomis there a clearcut choice of black or white but a selection from a collection of many shades of grey; we have to pick the 'best buy'.
Human beings as a whole have the responsibility of facing changes brought about by their own actions and a thorough and right science background can, in many cases, provide the knowledge to make assessments and wise choices. Scientific knowledge can also provide a background for the study of the historical and social consequences of man's past activities.

What was the effect of the closing down of the Cornish tin mines ? What was the effect of the production of synthetic dyes ? Or the cheap manufacture of soda leading to cheap soap ? Science often provides the data for a reasoned assessment to be made.

**There is one river which is considered to be a fire risk !*

Appendix 1

Experiments with wind: a pendulum anemometer

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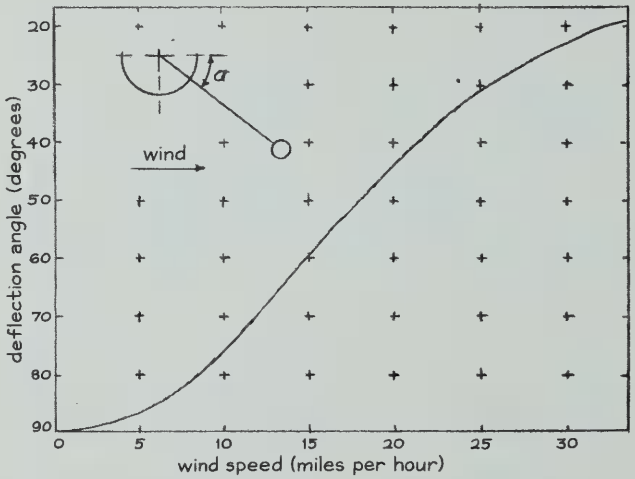
How strong is the wind ? The question is readily answered with an anemometer. In most of these instruments the flow of air around an obstruction develops a force that varies with wind speed. The force determines the position of a pointer on a scale that is calibrated in units of speed. One popular anemometer consists of a small windmill that spins an electric generator. The output of the generator varies with the velocity of the windmill and is measured by a calibrated meter.

Many anemometers of this type have been built by amateurs. The instruments are easy to make and convenient to use but difficult to calibrate. The problem of calibration has now been solved with a portable anemometer that can also be used as a secondary standard. The instrument was developed a few months ago by P. L. Clemens while he was serving as visiting professor at the Von Karman Institute for Fluid Dynamics at Rhode-Saint-Genese in Belgium. Clemens discusses the calibration of anemometers and the construction of his new instrument as follows:

'The techniques of calibrating anemometers tend toward two extremes: accurate but expensive and simple but inaccurate. Wind-tunnel calibrations fall in the first category. Good wind tunnels are not readily available, and the cost of their operation is beyond the resources of most experimenters. For this reason many amateurs have resorted to a calibration procedure of the second kind. In that procedure the instrument to be calibrated is supported



Calibration graph of the anemometer

outside a moving automobile. The scale is graduated by reading the speedometer as the vehicle accelerates through a series of test velocities.

'It is difficult to imagine a more hazardous and unreliable method of calibration. The details of the procedure tend to distract the driver even though others make the observations and record the data. Moreover, the data are likely to be in error. Automobile speedometers are rarely accurate at low velocities, which are of most interest in the anemometry of sports. Attempts to average out the movement of the local air mass by such expedients as heading into the wind while making one set of observations and then reversing course for another set usually fail because of variations with time in the direction and speed of the local air. In addition the anemometer under calibration is immersed in a field of aerodynamic flow disturbed by the automobile.

The velocity of the air in this field usually differs substantially from the gross velocity of the automobile. Experimenters who rely on this method of calibrating are lucky to emerge from the experience with a scale error of less than 30 per cent.

'It was in response to the need for a simple and reasonably accurate method of calibrating anemometers that I undertook the design of the instrument I shall describe. It is a pendulum anemometer, consisting of a pendulum bob suspended at the centre of a protractor. When the pendulum swings in the plane that contains the velocity vector of the wind, the resulting force deflects the pendulum from the vertical at an angle that varies with wind velocity. The angle is a measure of the speed of the wind.

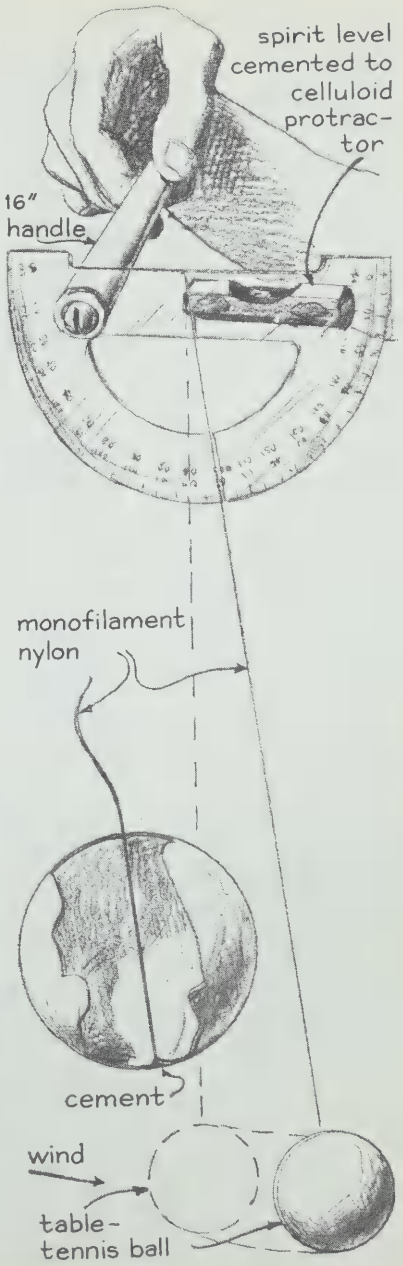
'The basic principle of the device dates back at least to the 15th century. My contribution consists in making a pendulum anemometer that can be duplicated exactly with inexpensive materials. The device was calibrated in a high-precision wind tunnel. The calibration can be transferred directly to all exact copies of the instrument.

The copies can be used either as secondary standards for calibrating anemometers of other types or as primary instruments for measuring air speed.

'The force that deflects the pendulum from the vertical arises primarily from the flow of air around the bob. If a spherical bob is tethered by a suspension of negligible area, the deflecting force is independent of the angle the pendulum makes with respect to the vertical, and the sensitivity is a function of the ballistic coefficient of the bob. The first consideration in the design of such an anemometer is the selection of a sphere capable of generating reasonable deflection angles through the anticipated range of wind velocity.

'The central problem with my instrument was finding a readily available and inexpensive sphere manufactured to close tolerances. Table-tennis balls proved to be ideal.

Manufacturers are obliged to meet rigid specifications of diameter and weight that have been established by the International Table Tennis Federation. The median diameter (37·7 millimetres) may vary by no more than 1·3 per cent and the weight (2·465 grams) by no more than 2·56 per cent.



'In choosing the suspension cord that supports the pendulum bob one must pay attention to the properties of the cord that might influence the performance of the anemometer. The cord should have a smooth surface, negligible weight and a small diameter. My first experiments were made with monofilament nylon cord having a diameter of ·08 millimeter and weighing ·011 gram per meter. This cord is available in sporting-goods shops and is commonly used to tie fishing flies. The breaking strength is about 400 grams. Monofilament nylon thread is also available in shops that sell sewing supplies. After my initial experiments I used cord of ·2-millimeter diameter with no observable difference in performance.

'The cord must be firmly attached to the ball. The attachment should add minimum weight to the assembly and should introduce minimum aerodynamic interference. To make the attachment I pierced the ball with a sewing needle at two diametrically opposite points. (The perforations also create two shallow indentations.) A needle threaded with the monofilament cord is passed through the ball. The free end of the cord is fastened to the ball with a dab of plastic cement. After the cement has hardened, surplus cord is trimmed as close as possible to the surface. Use a cement that does not attack the ball chemically. Test weighings indicate that the cementing operation, when performed with reasonable care, adds less than a milligram to the mass of the ball.

'The upper end of the suspension cord is passed through the index hole of an ordinary plastic protractor. The protractor serves as the scale for measuring the angular deflection of the pendulum with respect to the horizontal. (This may seem to conflict with the previous statement that the angle is measured with respect to the vertical. Mathematically the angles are complementary. Measuring with respect to the horizontal is a convenience in that it conforms to the usual scale markings on commercially made protractors.)

'Adjust the length of cord between the upper surface of the ball and the index hole of the protractor to 30 centimeters (12 inches) and attach the free end of the cord to the rear surface of the protractor with cement. Similarly, cement an ordinary spirit level parallel to and near the base line of the protractor [*see illustration on page 64*]. A baton about 40 centimeters long should be attached to the assembly. The baton can be made of wood dowel stock about half an inch in diameter. The baton enables the observer to support the instrument beyond the zone of disturbed air that surrounds his body. Wind-tunnel measurements indicate that the presence of the observer has a negligible effect on the measurements if he remains at least three body diameters toward one side of the instrument and does not move upstream.

'The aerodynamic characteristics of the instrument were determined by a series of measurements made in a wind tunnel. From these data I derived an equation that expresses the calibration at standard conditions of atmospheric pressure and temperature. Air speed is equal to a constant multiplied by the square root of the cotangent of the pendulum angle indicated by the protractor: $u = 19{\cdot}59(\cot \alpha)^{1/2}$, in which u is the air speed in miles per hour and α is the angle. The resulting calibration is listed in the accompanying table [*next page*]. The data are also plotted as a graph [*see illustration on page 64*].

'Significant error may be introduced as atmospheric pressure and temperature depart from standard conditions. For maximum accuracy such departures must be taken into account. The equation, as modified to include these corrections, is $u = 31{\cdot}72[(\cot \alpha)\ (T + 273)/P]^{1/2}$, where T is the temperature in degrees Celsius and P is atmospheric pressure in millimeters of mercury.

'In using the instrument one stands with the right shoulder facing into the wind. Grasp the baton in the right hand and hold the instrument at arm's length. Level the protractor and read the deflection of the pendulum

directly from the scale. The contrast between the cord and the scale can be increased by applying a dab of coloured enamel to the cord in the zone where it crosses the scale.

As with any anemometer, the observer should select an open area, free of obstructions to windward. Velocity gradients and turbulent eddies can be expected downwind from buildings, trees, shrubbery, fences and the observer himself. By the same token do not expect to make accurate measurements near the edge of a boat. Rain or spray that wets the ball increases its weight and decreases accuracy. The bob responds quickly to gusts and lulls, causing the pendulum to oscillate. The knack of reading maximum and minimum indications of the oscillating pendulum to find the average value of the angle comes with practice. Under most conditions the accuracy of the measurements is better than 6 per cent.'

Angle	Miles per Hour	Metres per Second	Angle	Miles per Hour	Metres per Second
55	16·4	7·33	20	32·5	14·5
56	16·1	7·20	21	31·6	14·1
57	15·8	7·06	22	30·8	13·8
58	15·5	6·93	23	30·1	13·5
59	15·2	6·79	24	29·4	13·1
60	14·9	6·66	25	28·7	12·8
61	14·6	6·52	26	28·1	12·5
62	14·3	6·39	27	27·5	12·3
63	14	6·26	28	26·9	12
64	13·7	6·12	29	26·3	11·8
65	13·4	5·98	30	25·8	11·5
66	13·1	5·85	31	25·3	11·3
67	12·8	5·71	32	24·8	11·1
68	12·5	5·57	33	24·3	10·9
69	12·1	5·43	34	23·9	10·7
70	11 8	5·29	35	23·4	10·5
71	11·5	5·14	36	23	10·3
72	11·2	5	37	22·6	10·1
73	19·6	4·85	38	22·2	9·91
74	10·5	4·69	39	21·8	9·74
75	10·1	4·54	40	21·4	9·57
76	9·79	4·38	41	21	9·40
77	9·42	4·21	42	20·7	9·24
78	9·04	4·04	43	20·3	9·08
79	8·64	3·86	44	19·9	8·92
80	8·23	3·68	45	19·6	8·76
81	7·80	3·49	46	19·3	8·61
82	7·35	3·29	47	18·9	8·46
83	6·87	3·07	48	18·6	8·32
84	6·36	2·84	49	18·3	8·17
85	5·80	2·59	50	18	8·03
86	5·18	2·32	51	17·6	7·89
87	4·49	2·01	52	17·3	7·75
88	3·66	1·64	53	17	7·61
89	2·59	1·16	54	16·7	7·47
90	0	0	55	16·4	7·33

Calibration table of the anemometer

Appendix 2

Three case histories and one flow chart showing the variety of work and approach

Case history 1. Urban district school

First term—beginning January 1971

Saw film strip of 'Homes in other countries'. Talk afterwards about our homes and things we have and use in them.

To start off (as I liked the ideas in the Units about activities with fabrics and washing) I bought a packet of as many detergents and washing powders I could find and put them on a table in the classroom. Immediately there was interest and talk, eg 'my mum always uses Persil', 'Square deal Surf is cheaper and just as good', etc, so we were off with the following activities:

i. Survey of the most popular powder used by mothers—children brought either a packet top or paper with name on and group of interested girls helped to sort and count and make a chart.

ii. Two boys became interested in noting prices and amounts—made a chart to see which was best value for money, working out price per oz as amounts and prices varied. After finding that Fine Fare was best value for money, group of girls decided to see how well each powder removed stains from cotton sheeting.

iii. Lots of ideas here, group tried various stains, eg orange squash, beetroot, then harder ones like grass and Biro, taking into account variables such as length of soaking, time of agitation, rinsing, etc.

iv. Two girls, after reading that 'water is a detergent but not a very good one' decided to try getting stains out with just water.

v. Group decided to test the advert that a towel washed in Persil many times (about thirty times I think they washed them) would be softer than one washed the same number of times in any other powder.

vi. Another group became interested in amount of water left in towels after spin-drying and how quickly a towel dried outside compared with inside. Also how much water was left in towel after using a hand wringer.

vii. Another group after presenting them with a pile of various fabrics tried to identify them from the key in the Unit *Coloured things Stages 1 & 2,* by burning.

viii. Different fabric properties were also tested: stretchability of various fabrics tested by hanging weights on fabric strips of equal lengths held by clamp. Crease-resistant properties by devising an experiment screwing up equal squares of fabric and putting them under books for so many days.
Fading qualities—tests by washing and leaving hanging in the light.

ix. Also looking at threads under microscope.

x. Two boys made apparatus (page 56, *Change,*) to measure evaporation.

xi. Activities on dyeing fabrics.

All these activities carried on into other subjects such as:

1. History and Geography topics
The story of a fifteenth-century wool merchant—story read to children who illustrated and made own books.
A nineteenth-century Lancashire weaver's family as above. This led to discussion on the Industrial Revolution and the cotton trade today.

2. Science film
Saw an excellent film on 'detergency' by Unilever—on how a detergent works in water. Children also wrote to Unilever and Hedley, etc, to obtain information and to a woollen mill in Scotland.

3. Art and craft
Designs in fabrics—display of wallpaper, curtain fabric, etc, led to children making own designs.

Practical weaving on cardboard and loom.

Dyeing.

Designing rooms in a box.

4. English and topic
Making books about costume through the ages.

5. Unit
To see sheep-shearing and other craft.

A talk about outside the home led to activities in the garden and weather.

Case history 2. Ten-year-olds. A school set in the dock area of a large city
The school was built in 1871 in the middle of a dock area in a large city. This class studied the changes that have taken place in our district over the last 100 years. This was part of our 'Centenary Year Celebration'.

Group 1 worked on the different types of houses in the district. (They vary in date from 1800 to 1972.) They took photographs with their Instamatic cameras of the different types of houses and noted points of interest.

They compared the houses built over 100 years ago with the modern flats and houses recently built.
A model street was made showing people in period costume.

Group 2 studied changes in church design.
Starting from our own church of which the children made a large model. They also made models of the city's two cathedrals. The design of the two cathedrals was compared.

Group 3 studied the buildings of the area.
They made a photographic record of the buildings and streets before they are knocked down for modern development.

They noted buildings that had changed in use over the years—eg mission to social centre, cinema to bingo club.

Group 4 studied the river and how ship design had changed over the last 100 years.

Some of the children took our portable tape recorder and interviewed people who had lived in the area for many years. Some remembered the sailing ships on the river, one man had sailed in them.

The science that became involved:

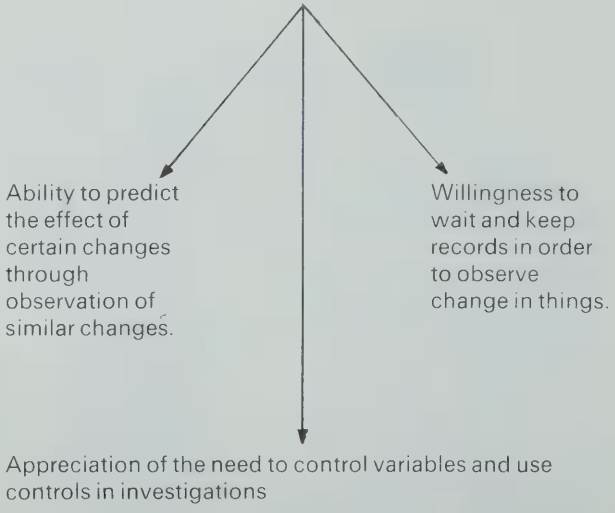
Foundations of buildings, cavity walls, damp-proof courses, heat retention of various materials, electric light, porosity of bricks, comparing bricks 100 years old with those of modern manufacture, sinking and floating, the Plimsoll Line, salt and fresh water, saturation point of salt water, movement in water, the best shape for boats, wind and direction.

An exhibition of work was held and many schools and training colleges sent parties to see the children's work. English, art, history, geography and science were all integrated in the project.

Case history 3. Rural school

Objectives

Knowledge of conditions which promote changes in living and non-living materials


Ability to predict the effect of certain changes through observation of similar changes.
Willingness to wait and keep records in order to observe change in things.
Appreciation of the need to control variables and use controls in investigations

Lines of investigation

Quite a large number of topics sprang to the minds of the children with reference to change, but in retrospect the ones which played a significant part in achieving objectives were:

Changes and seeds.

Changes and development.

As a result of continuous observation of changes actually taking place in the classroom the children have become aware of the rhythmical patterns in growth and are beginning to appreciate the concept of life-cycles. Nevertheless there is still a lot to be done to raise the standard of their approach. It could not be called a scientific approach to problems. One must keep in mind the fact that this method of working is new to them this year and in many respects they are still at Stage 1.

Experiments
1. Germination of beans, peas, cress, lettuce, parsley, flower seeds, ornamental gourds.

2. To find what conditions are necessary for growth. The ornamental gourds grown from seed provided excellent material, having male and female flowers.

In the latter the number of variables was rather confusing. but it served to hammer home the fact that there were such things as variables and there was a need for controls.

Beans and peas were put in jam jars with blotting paper and sawdust, in one case with light, air and warmth but no water. Another had water, air and warmth but no light. And so on.

Potatoes were also tried out in varying conditions. Onions were set on top of stones and water. Carrot tops were placed on saucers. Curiously enough the children expected the carrot top to grow into a carrot and the onion to grow into a fat onion. Great was their excitement the day the carrot top flowered.

Development of living things
As well as studying changes in the development of plants we had an excellent chance to do this with the tadpoles we were able to care for until they turned into frogs. One batch of frogs were exceedingly tiny and very black and I think their chances of survival were slim. They probably needed more protein too. We took them back.

The study of life in the aquarium gave us a very good idea of water creatures which seem to live together. Again, there was a difference between the pond and the river collections.

Other topics connected with change which were studied by small groups, sometimes only two pupils, were:

a. Change and wheels.

b. Change and temperature.

c. Change and money (decimal currency).

d. Change and soil.

e. Change of a river (River Tweed).

f. Chemical change (mixing salt, bicarbonate of soda, etc, with water and reversing the change).

g. Change and colour.

h. Seasonal changes in trees.

i. Erosion.

j. Salmon and eels and environmental change.

k. Changes on maps.

l. Change and transport.

An excellent piece of work on the last mentioned was done by a country boy about the farm on which his father is shepherd. He was quick to observe differences between old Ordnance Survey markings and what he could see today and traced the historical as well as the geographical development of 'Ladyrig'. When the Primary Adviser produced an up-to-date Ordnance Survey map for him, he was quick to relate the markings to what he had observed.

Another group of boys studied changes in Kelso, by comparing a map of 1852 with present layout. They were particularly interested in how much certain bends in the Tweed had been eroded by the river over the years. They tried to make two maps to compare but, as the measurements in the 1852 map were in chains they found this beyond them and I had to come to the rescue.

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Water Supply

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Solarbo Book of Balsa Models, Model and Allied Publications

Index to objectives

Introduction to the index to objectives

Understanding the index

The index relates the Statement of Objectives for Children Learning Science to the Unit.

It has page references to places in the Unit where ways in which children might achieve particular objectives are illustrated. The objectives are not however stated in full: for easy reference they are listed by numbers corresponding to the numbering on the main statement.

The index is not comprehensive or exhaustive.

It cannot be *comprehensive* because:

i. the objectives are but one selection of many possibilities (see page 30 *With objectives in mind*).

ii. the Units contain ideas through which many unlisted objectives could be achieved.

iii. we hope that teachers will form their own objectives.

It cannot be *exhaustive* because:

i. the written word is inadequate for conveying complete appreciation of situations which are essentially active.

ii. only the more obvious examples of activities relating to each objective are indexed: others, equally valuable, have not been cited.

The index has value only within the context of working with the objectives in mind.

It is included to help those trying to work in this way, and suggestions for using it are set out below.

Making use of the index

The index can be used to clarify what is meant by the wording of particular objectives.

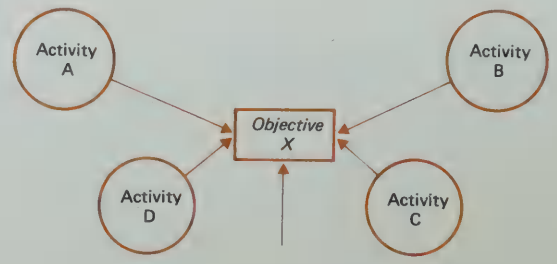
The particular wording of our objectives results from trying to sum up as succinctly as possible notions which might take pages to explain fully. We think that the best way to give these statements meaning is through illustration in terms of children's activities. This can be done by using the 'General Index' to objectives which is included in *With objectives in mind.*

In the index the entries against any one objective give page references to activities in the Unit, and each reference will show what the objective means in operation in a particular context.

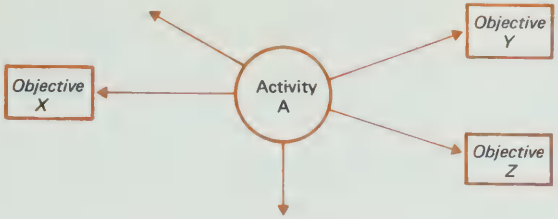
By looking up several references to the same objective it is possible to build up an appreciation of what that objective means in practical terms. In this way teachers can build up operational definitions of the objectives.

The index can help understanding of the relationship which exists between objectives and activities.

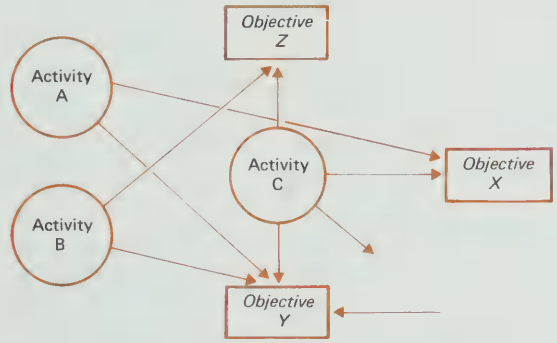
Objectives at the level of generality of our statements are not the kind that can be attained through a single experience. They will be achieved as a result of experience from several contributory activities.



But a teacher will have many objectives for her children in mind at any one time, and in general there is potential for working towards several objectives through any one activity:



So the relationship between objectives and activities is best represented as a complex mesh:



Looking through the index gives indication of this relationship: Several entries to objectives may refer to one activity. One objective has many entries against it to different activities.

The index indicates the many different objectives to which the work of a Unit can relate.
In each of the Units for teachers certain objectives are stated or referred to at several points. These are the objectives most relevant to the particular Unit, ones whose achievement is likely to be the aim of teachers when their children are working in the subject area covered by the Unit. But they are only some of the objectives which the work can help to achieve. There are many others not mentioned in the text because they are so numerous and appear so frequently that to mention them would interfere with the description of suggested activities.

Teachers will find that reference to the index brings to light the many different objectives to which the work of the Unit relates, and that it does so in a way that does not affect the continuity of the Unit.

The index can give ideas for progression towards particular objectives.
When children have achieved objectives at one stage and are ready for progress towards more advanced objectives, teachers may like help with ideas of how to encourage this progression.

Suppose a child or group has reached an *awareness that more than one variable may be involved in a particular change* and the teacher feels she would like to encourage *ability to investigate variables and discover effective ones.* She may like some ideas how to guide discoveries so as to promote this. If so she may find this help by turning to examples, found by means of the index, of activities and approaches through which the objective might be achieved in various contexts. She may or may not want to follow any of the suggestions closely, but at least she may gain ideas to apply to problems the children are currently engaged upon.

Attitudes, interests and aesthetic awareness.
Objectives stated under this broad aim relate more to children's general readiness to respond in certain ways than to changes in their intellectual abilities. These objectives permeate the activities suggested in the Units to a much greater extent than do the rest of the objectives and this makes them particularly difficult to index. References to them in the text should be regarded as examples only: it is not possible for us to index any objectives comprehensively, these least of all. Indeed there are some attitude and interest objectives which are relevant to every activity; for these it has not seemed to us appropriate to select even a few examples to note in the margins. These are such objectives:

Stage 1:
1.01 Willingness to ask questions.

1.02 Willingness to handle both living and non-living materials.

1.06 Desire to find out things for oneself.

1.07 Willing participation in group work.

1.08 Willingness to comply with safety regulations in handling tools & equipment.

1.09 Appreciation of the need to learn the meaning of new words and to use them correctly.

Stage 2:
2.01 Willingness to co-operate with others in science activities.

2.03 Appreciation of the reasons for safety regulations.

Stage 3:
3.01 Acceptance of responsibility for their own and others' safety in experiments.

3.02 Preference for using words correctly.

We think that teachers will want to keep these objectives in mind all the time So, to avoid constant repetition of the same numbers, references to them are not given in the margins of any text. The index, however, includes a reminder that they could be relevant everywhere.

Index to objectives

Broad aim	Objective reference number	Page number of Unit
.00/.10 Attitudes, interests and aesthetic awareness	1.01	Everywhere
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Broad aim	Objective reference number	Page number of Unit
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.30 Developing basic concepts and logical thinking	1.31 1.32	Everywhere
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.40 Posing questions and devising experiments or investigations to answer them	1.41	14, 16, 35, 44, 45, 52
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.50/.60 Acquiring knowledge and learning skills	1.51	Implicit
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	1.62	Implicit
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Broad aim	Objective reference number	Page number of Unit
.50/.60 Acquiring knowledge and learning skills (continued)	2.53	24
	2.54	Implicit
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.90 Interpreting findings critically	1.91	39, 40
	1.92	25, 35
	2.92	Implicit
	2.93	60

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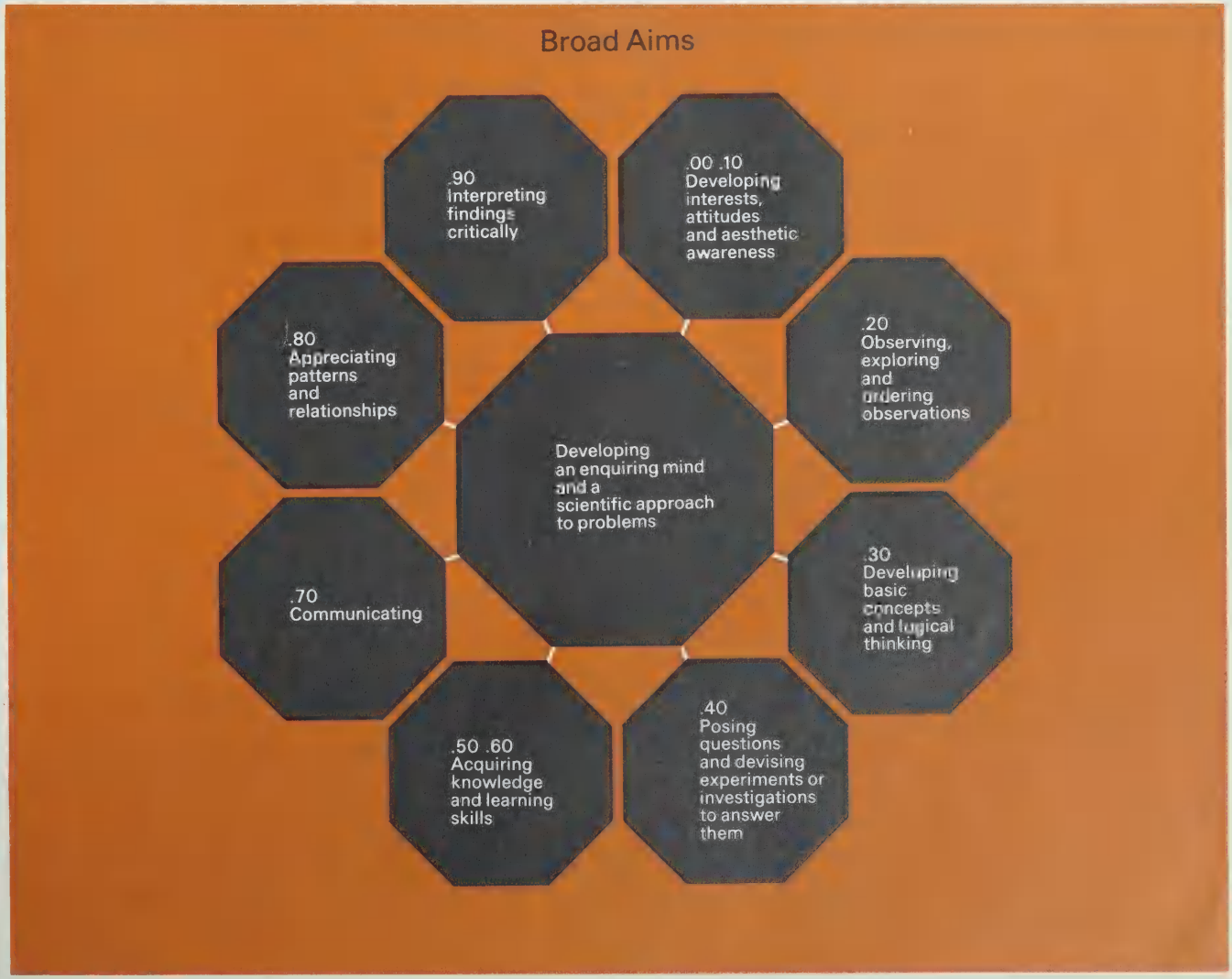
Objectives for children learning science

Guide lines to keep in mind


Broad Aims
.90 Interpreting findings critically
.00 .10 Developing interests, attitudes and aesthetic awareness
.80 Appreciating patterns and relationships
.20 Observing, exploring and ordering observations
Developing an enquiring mind and a scientific approach to problems
.70 Communicating
.30 Developing basic concepts and logical thinking
.50 .60 Acquiring knowledge and learning skills
.40 Posing questions and devising experiments or investigations to answer them

What we mean by Stage 1, Stage 2 and Stage 3

Attitudes, interests and aesthetic awareness

.00/.10

Stage 1
Transition from intuition to concrete operations. Infants generally.

The characteristics of thought among infant children differ in important respects from those of children over the age of about seven years. Infant thought has been described as 'intuitive' by Piaget; it is closely associated with physical action and is dominated by immediate observation. Generally, the infant is not able to think about or imagine the consequences of an action unless he has actually carried it out, nor is he yet likely to draw logical conclusions from his experiences. At this early stage the objectives are those concerned with active exploration of the immediate environment and the development of ability to discuss and communicate effectively: they relate to the kind of activities that are appropriate to these very young children, and which form an introduction to ways of exploring and of ordering observations.

1.01 Willingness to ask questions
1.02 Willingness to handle both living and non-living material.
1.03 Sensitivity to the need for giving proper care to living things.
1.04 Enjoyment in using all the senses for exploring and discriminating.
1.05 Willingness to collect material for observation or investigation.

Concrete operations. Early stage.

In this Stage, children are developing the ability to manipulate things mentally. At first this ability is limited to objects and materials that can be manipulated concretely, and even then only in a restricted way. The objectives here are concerned with developing these mental operations through exploration of concrete objects and materials—that is to say, objects and materials which, as physical things, have meaning for the child. Since older children, and even adults prefer an introduction to new ideas and problems through concrete example and physical exploration, these objectives are suitable for all children, whatever their age, who are being introduced to certain science activities for the first time.

1.06 Desire to find out things for oneself.
1.07 Willing participation in group work.
1.08 Willing compliance with safety regulations in handling tools and equipment.
1.09 Appreciation of the need to learn the meaning of new words and to use them correctly.

Stage 2
Concrete operations. Later stage.

In this Stage, a continuation of what Piaget calls the stage of concrete operations, the mental manipulations are becoming more varied and powerful. The developing ability to handle variables—for example, in dealing with multiple classification—means that problems can be solved in more ordered and quantitative ways than was previously possible. The objectives begin to be more specific to the exploration of the scientific aspects of the environment rather than to general experience, as previously. These objectives are developments of those of Stage 1 and depend on them for a foundation. They are those thought of as being appropriate for all children who have progressed from Stage 1 and not merely for nine- to eleven-year-olds.

2.01 Willingness to co-operate with others in science activities.
2.02 Willingness to observe objectively.
2.03 Appreciation of the reasons for safety regulations.
2.04 Enjoyment in examining ambiguity in the use of words.
2.05 Interest in choosing suitable means of expressing results and observations.
2.06 Willingness to assume responsibility for the proper care of living things.
2.07 Willingness to examine critically the results of their own and others' work.
2.08 Preference for putting ideas to test before accepting or rejecting them.
2.09 Appreciation that approximate methods of comparison may be more appropriate than careful measurements.

Stage 3
Transition to stage of abstract thinking.

This is the Stage in which, for some children, the ability to think about abstractions is developing. When this development is complete their thought is capable of dealing with the possible and hypothetical, and is not tied to the concrete and to the here and now. It may take place between eleven and thirteen for some able children, for some children it may happen later, and for others it may never occur. The objectives of this stage are ones which involve development of ability to use hypothetical reasoning and to separate and combine variables in a systematic way. They are appropriate to those who have achieved most of the Stage 2 objectives and who now show signs of ability to manipulate mentally ideas and propositions.

3.01 Acceptance of responsibility for their own and others' safety in experiments.
3.02 Preference for using words correctly.
3.03 Commitment to the idea of physical cause and effect.
3.04 Recognition of the need to standardise measurements.
3.05 Willingness to examine evidence critically.
3.06 Willingness to consider beforehand the usefulness of the results from a possible experiment.
3.07 Preference for choosing the most appropriate means of expressing results or observations.
3.08 Recognition of the need to acquire new skills.
3.09 Willingness to consider the role of science in everyday life

Attitudes, interests and aesthetic awareness .00/.10	Observing, exploring and ordering observations .20
	1.21 Appreciation of the variety of living things and materials in the environment. *1.22* Awareness of changes which take place as time passes. *1.23* Recognition of common shapes—square, circle, triangle. *1.24* Recognition of regularity in patterns. *1.25* Ability to group things consistently according to chosen or given criteria.
1.11 Awareness that there are various ways of testing out ideas and making observations. *1.12* Interest in comparing and classifying living or non-living things. *1.13* Enjoyment in comparing measurements with estimates. *1.14* Awareness that there are various ways of expressing results and observations. *1.15* Willingness to wait and to keep records in order to observe change in things. *1.16* Enjoyment in exploring the variety of living things in the environment. *1.17* Interest in discussing and comparing the aesthetic qualities of materials.	*1.26* Awareness of the structure and form of living things. *1.27* Awareness of change of living things and non-living materials. *1.28* Recognition of the action of force *1.29* Ability to group living and non-living things by observable attributes. *1.29a* Ability to distinguish regularity in events and motion.
2.11 Enjoyment in developing methods for solving problems or testing ideas. *2.12* Appreciation of the part that aesthetic qualities of materials play in determining their use. *2.13* Interest in the way discoveries were made in the past.	*2.21* Awareness of internal structure in living and non-living things. *2.22* Ability to construct and use keys for identification. *2.23* Recognition of similar and congruent shapes. *2.24* Awareness of symmetry in shapes and structures. *2.25* Ability to classify living things and non-living materials in different ways. *2.26* Ability to visualise objects from different angles and the shape of cross-sections.
3.11 Appreciation of the main principles in the care of living things. *3.12* Willingness to extend methods used in science activities to other fields of experience.	*3.21* Appreciation that classification criteria are arbitrary. *3.22* Ability to distinguish observations which are relevant to the solution of a problem from those which are not. *3.23* Ability to estimate the order of magnitude of physical quantities.

	Developing basic concepts and logical thinking .30	Posing questions and devising experiments or investigations to answer them .40
Stage 1 Transition from intuition to concrete operations. Infants generally.	*1.31* Awareness of the meaning of words which describe various types of quantity. *1.32* Appreciation that things which are different may have features in common.	*1.41* Ability to find answers to simple problems by investigation. *1.42* Ability to make comparisons in terms of one property or variable.
Concrete operations. Early stage.	*1.33* Ability to predict the effect of certain changes through observation of similar changes. *1.34* Formation of the notions of the horizontal and the vertical. *1.35* Development of concepts of conservation of length and substance. *1.36* Awareness of the meaning of speed and of its relation to distance covered.	*1.43* Appreciation of the need for measurement. *1.44* Awareness that more than one variable may be involved in a particular change.
Stage 2 Concrete operations. Later stage.	*2.31* Appreciation of measurement as division into regular parts and repeated comparison with a unit. *2.32* Appreciation that comparisons can be made indirectly by use of an intermediary. *2.33* Development of concepts of conservation of weight, area and volume. *2.34* Appreciation of weight as a downward force. *2.35* Understanding of the speed, time, distance relation.	*2.41* Ability to frame questions likely to be answered through investigations. *2.42* Ability to investigate variables and to discover effective ones. *2.43* Appreciation of the need to control variables and use controls in investigations. *2.44* Ability to choose and use either arbitrary or standard units of measurement as appropriate. *2.45* Ability to select a suitable degree of approximation and work to it. *2.46* Ability to use representational models for investigating problems or relationships.
Stage 3 Transition to stage of abstract thinking.	*3.31* Familiarity with relationships involving velocity, distance, time, acceleration. *3.32* Ability to separate, exclude or combine variables in approaching problems. *3.33* Ability to formulate hypotheses not dependent upon direct observation. *3.34* Ability to extend reasoning beyond the actual to the possible. *3.35* Ability to distinguish a logically sound proof from others less sound.	*3.41* Attempting to identify the essential steps in approaching a problem scientifically. *3.42* Ability to design experiments with effective controls for testing hypotheses. *3.43* Ability to visualise a hypothetical situation as a useful simplification of actual observations. *3.44* Ability to construct scale models for investigation and to appreciate implications of changing the scale.

Acquiring knowledge and learning skills

.50/.60

1.51 Ability to discriminate between different materials.
1.52 Awareness of the characteristics of living things.
1.53 Awareness of properties which materials can have.
1.54 Ability to use displayed reference material for identifying living and non-living things.

1.55 Familiarity with sources of sound.
1.56 Awareness of sources of heat, light and electricity.
1.57 Knowledge that change can be produced in common substances.
1.58 Appreciation that ability to move or cause movement requires energy.
1.59 Knowledge of differences in properties between and within common groups of materials.

2.51 Knowledge of conditions which promote changes in living things and non-living materials.
2.52 Familiarity with a wide range of forces and of ways in which they can be changed.
2.53 Knowledge of sources and simple properties of common forms of energy.
2.54 Knowledge of the origins of common materials.
2.55 Awareness of some discoveries and inventions by famous scientists.
2.56 Knowledge of ways to investigate and measure properties of living things and non-living materials.
2.57 Awareness of changes in the design of measuring instruments and tools during man's history.
2.58 Skill in devising and constructing simple apparatus.
2.59 Ability to select relevant information from books or other reference material.

3.51 Knowledge that chemical change results from interaction.
3.52 Knowledge that energy can be stored and converted in various ways.
3.53 Awareness of the universal nature of gravity.
3.54 Knowledge of the main constituents and variations in the composition of soil and of the earth.
3.55 Knowledge that properties of matter can be explained by reference to its particulate nature.
3.56 Knowledge of certain properties of heat, light, sound, electrical, mechanical and chemical energy.
3.57 Knowledge of a wide range of living organisms.
3.58 Development of the concept of an internal environment.
3.59 Knowledge of the nature and variations in basic life processes.

Acquiring knowledge and learning skills

.50/.60

1.61 Appreciation of man's use of other living things and their products.
1.62 Awareness that man's way of life has changed through the ages.
1.63 Skill in manipulating tools and materials.
1.64 Development of techniques for handling living things correctly.
1.65 Ability to use books for supplementing ideas or information.

3.61 Appreciation of levels of organisation in living things.
3.62 Appreciation of the significance of the work and ideas of some famous scientists.
3.63 Ability to apply relevant knowledge without help of contextual cues.
3.64 Ability to use scientific equipment and instruments for extending the range of human senses.

	Communicating	Appreciating patterns and relationships
	.70	.80
Stage 1 Transition from intuition to concrete operations. Infants generally.	*1.71* Ability to use new words appropriately. *1.72* Ability to record events in their sequences. *1.73* Ability to discuss and record impressions of living and non-living things in the environment. *1.74* Ability to use representational symbols for recording information on charts or block graphs.	*1.81* Awareness of cause-effect relationships.
Concrete operations. Early stage.	*1.75* Ability to tabulate information and use tables. *1.76* Familiarity with names of living things and non-living materials. *1.77* Ability to record impressions by making models, painting or drawing.	*1.82* Development of a concept of environment. *1.83* Formation of a broad idea of variation in living things. *1.84* Awareness of seasonal changes in living things. *1.85* Awareness of differences in physical conditions between different parts of the Earth.
Stage 2 Concrete operations. Later stage.	*2.71* Ability to use non-representational symbols in plans, charts, etc. *2.72* Ability to interpret observations in terms of trends and rates of change. *2.73* Ability to use histograms and other simple graphical forms for communicating data. *2.74* Ability to construct models as a means of recording observations.	*2.81* Awareness of sequences of change in natural phenomena. *2.82* Awareness of structure-function relationship in parts of living things. *2.83* Appreciation of interdependence among living things. *2.84* Awareness of the impact of man's activities on other living things. *2.85* Awareness of the changes in the physical environment brought about by man's activity. *2.86* Appreciation of the relationships of parts and wholes.
Stage 3 Transition to stage of abstract thinking.	*3.71* Ability to select the graphical form most appropriate to the information being recorded. *3.72* Ability to use three-dimensional models or graphs for recording results. *3.73* Ability to deduce information from graphs: from gradient, area, intercept. *3.74* Ability to use analogies to explain scientific ideas and theories.	*3.81* Recognition that the ratio of volume to surface area is significant. *3.82* Appreciation of the scale of the universe. *3.83* Understanding of the nature and significance of changes in living and non-living things. *3.84* Recognition that energy has many forms and is conserved when it is changed from one form to another. *3.85* Recognition of man's impact on living things—conservation, change, control. *3.86* Appreciation of the social implications of man's changing use of materials, historical and contemporary. *3.87* Appreciation of the social implications of research in science. *3.88* Appreciation of the role of science in the changing pattern of provision for human needs.

Interpreting findings critically

.90

1.91 Awareness that the apparent size, shape and relationships of things depend on the position of the observer.

1.92 Appreciation that properties of materials influence their use.

2.91 Appreciation of adaptation to environment.
2.92 Appreciation of how the form and structure of materials relate to their function and properties.
2.93 Awareness that many factors need to be considered when choosing a material for a particular use.
2.94 Recognition of the role of chance in making measurements and experiments.

3.91 Ability to draw from observations conclusions that are unbiased by preconception.
3.92 Willingness to accept factual evidence despite preceptual contradictions.
3.93 Awareness that the degree of accuracy of measurements has to be taken into account when results are interpreted.
3.94 Awareness that unstated assumptions can affect conclusions drawn from argument or experimental results.
3.95 Appreciation of the need to integrate findings into a simplifying generalisation.
3.96 Willingness to check that conclusions are consistent with further evidence.

These Stages we have chosen conform to modern ideas about children's learning. They conveniently describe for us the mental development of children between the ages of five and thirteen years, but it must be remembered that ALTHOUGH CHILDREN GO THROUGH THESE STAGES IN THE SAME ORDER THEY DO NOT GO THROUGH THEM AT THE SAME RATES.
SOME children achieve the later Stages at an early age.
SOME loiter in the early Stages for quite a time.
SOME never have the mental ability to develop to the later Stages.
ALL appear to be ragged in their movement from one Stage to another.
Our Stages, then, are not tied to chronological age, so in any one class of children there will be, almost certainly, some children at differing Stages of mental development.

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Illustration acknowledgements:

The publishers gratefully acknowledge the help given by the following in supplying photographs on the pages indicated:

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Mervyn Rees, 42 (bottom)
John Topham, 26 (bottom right)
United States Travel Service, 17
James Wright, 29
Yachts and yachting, 26 (top right)

Line drawings by Pamela Mara

Cover design by Peter Gauld

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CHANGE STAGES 1 AND 2 AND
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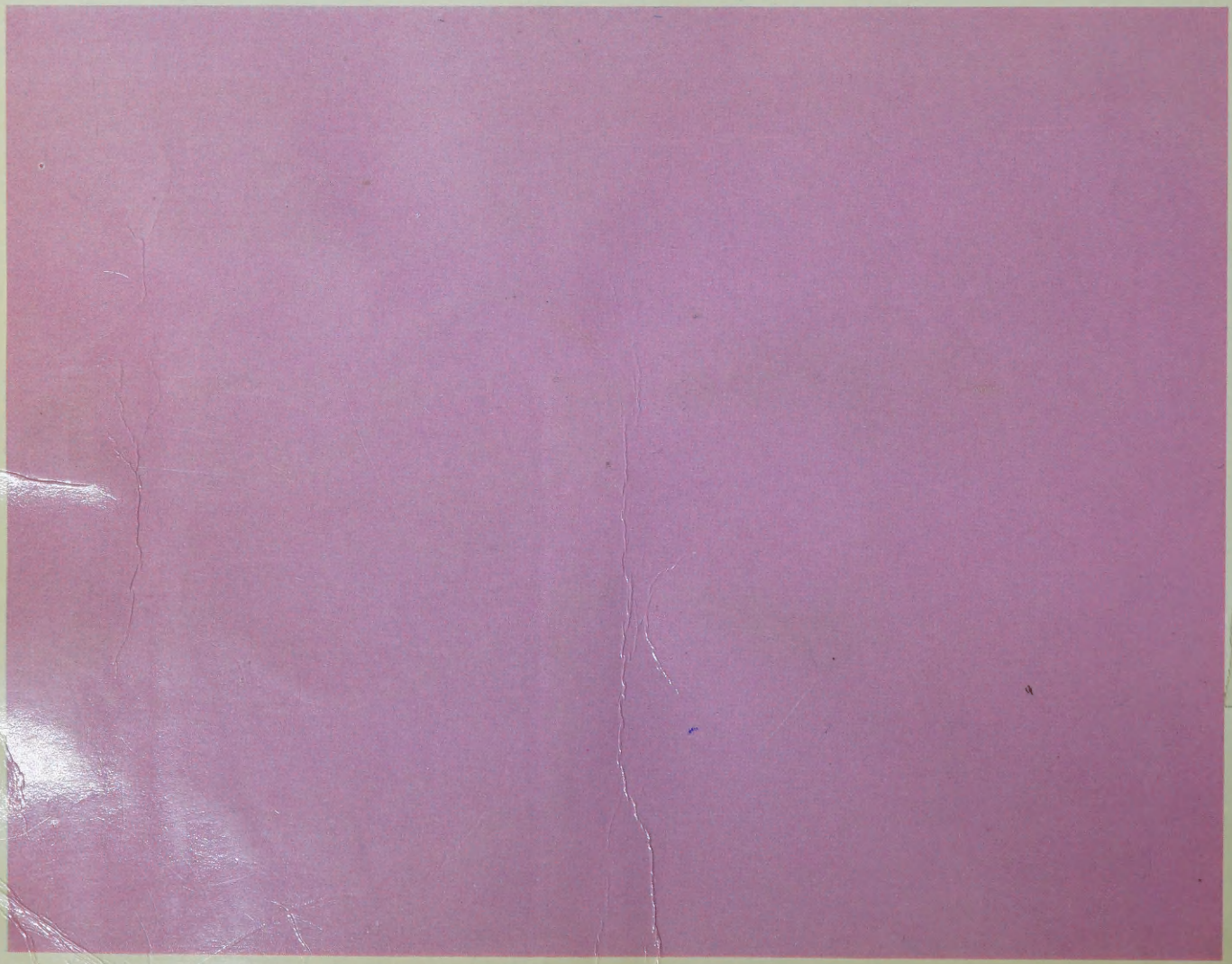

ISBN 0 356 04105 0